MAN AND ENVIRONMENT

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AKADÉMIAI KIADÓ · BUDAPEST

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Geographers have long been concerned with the challenging questions of the relationship between nature and society. Although the recent and future problems emerging from man's endeavour to influence his environment, e.g. the rational use of non-renewable resources, the control of different kinds of pollution etc., require a complex, interdisciplinary approach, geographers with a background in both physical and social sciences have an important contribution to do. The role of modern geography in the environmental research was discussed — first of all from a theoretical point of view — by prominent representatives of the discipline at the I.G.U. European Regional Conference, held in Budapest, 1971. At the same time a broad set of case-studies presented an excellent cross-section of contemporary research carried out by geographers on their own, or in a frame of interdisciplinary co-operation.

MAN AND ENVIRONMENT

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MAN AND ENVIRONMENT

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PRESIDENTIAL ADDRESS

It is not simply formal politeness when I express the best wishes of the Earth and Mining Department of the Hungarian Academy of Sciences and of my own to the Conference of the International Geographic Union and especially to the First Section of this Conference.

This section investigates the relations of man and his geographical environment, and hence is engaged in the basic question of the social impact of geonomic conditions.

For several years, the main objective of the Earth and Mining Department of the Hungarian Academy of Sciences, including my own geochemical-geotectonic researches, has been to explore the basic principles connecting the different earth sciences, that is the fundamental geonomic relations. To clarify the fundamental relations of geonomics is of primary importance for the progress of earth sciences and hence for the social development of mankind.

It is no longer an illusion that pragmatic cooperation between the earth sciences, that is geonomy, may be of considerable advantages for social development.

According to a distinguished member of this conference, "studies of the physical formations must be carried out on a wide scientific front, keeping in view the unity of the natural environment and the close interrelations among its components".

My addition to this important statement is that recent investigations of the mechanism of the new global tectonics have shown that the horizontal displacement of the lithosphere and its recent as well as old subductions into the mantle belong to this "unity" of the natural environment. Indeed it is one of the most fundamental factors of development in the natural environment of man.

The scientific recognition and possible utilization of this mechanism results in enormous mental and financial advantages for mankind. There are forces in this mechanism which, contrary to present public belief, exceed by many orders of magnitude the effectivity of the technical means known so far and also the possibilities of human destructive forms.

The transformation of nature is productive when it parallels these geonomic forces, although it disappears within a short time. When, however, it acts against these forces it becomes needless and harmful waste of energy.

From the point of view of man and his environment some understanding of this mechanism has developed. First of all, tectonic zones proved to be important, in which the lithosphere, especially its sedimentary cover is subducting into the mantle. These subduction zones, when young and active, indicate increased difficulties for settlement. Earth movements are concentrated in the recently active subduction zones, and disappearance of land has to be taken into account in these places as well. However, along older subduction zones of diminishing activity raw materials of great human significance are accumulated, such as hydrocarbon deposits, young igneous ore deposits, and geothermal energy and water resources. Subduction zones, therefore, are of great importance in the field of economic planning and in the development of industrial regions and metropolitan areas. Their effects must also be considered in the solution of the problem of pollution and other harmful activities connected with industrialization.

According to the latest investigations, the whole dynamism of the earth is connected with the subduction or subsidence of sedimentary rocks, especially the clayey components, in the mantle. The mobility of the lithosphere is due to the effect of the sub-orogenic vapour centre and to the sub-lithospheric vapour-pillow originating at great depths from the release of chemically held water from subducted clay minerals. Clay-mineral formation is, however, considerably promoted by the biological factor, namely by soil formation, and especially by the human activity of soil cultivation.

As a result of the increased bio-mass and of the lengthy technical activity of mankind, the processes taking place in the subduction zone are intensified. Hence, in the youngest geological periods the dynamism of the earth has increased, and global tectonic activity has risen.

Even closer and quantifiable relationships between the lithosphere, hydrosphere, atmosphere and biosphere have been recognized by recent advances in geonomics, all of which promote long-term economic forecastings, and hence regional planning.

But it is not only geonomy that provides new horizons for geography and for the investigation of the human environment, for in this period of rapid development geonomy itself increasingly needs new geographical information. More detailed information on the erosion and accumulation rates increased by natural and anthropogenic effects is of great significance from the point of view of global dynamics.

Our times are producing a general revolution in the earth sciences, and recent interdisciplinary progress presents quite new aspects of the problems of man and his environment. Therefore the proceedings of this section are awaited with keen interest by many earth-scientists in Hungary and in the world.

E. Szádeczky-Kardoss

I. MAN AND ENVIRONMENT IN MODERN GEOGRAPHY

ENVIRONMENT AND THE RATIONAL USE OF NATURAL RESOURCES

by

I. P. GERASIMOV

It is known that the problems of the environment surrounding man and used by society to meet people's various material and cultural requirements have long been the subject of scientific research. The investigators' attention has been drawn until recently to two main aspects of these problems: the first is the influence of the environment on human activities and the second is the effect of human activities on the environment and their consequences. At present, however, a third aspect, linking the other two, attracts more and more attention. It is the feedback of the said phenomena, namely, the influence of the environment greatly changed by man on the conditions of subsequent existence and the activities of human society.

Indeed, in our times we witness a powerful flow of scientific and popular-scientific literature, as well as publicity, devoted to the problem of "Man and Environment". This literature has until recently mainly concentrated upon appealing for the protection of nature which is rapidly deteriorating under the increasing impact of modern civilization. Special attention has been focused on preventing the final disappearance of many species of plants and animals and their associations under the changed environmental conditions. One of the basic ways of solving such problems has been to restrict hunting and fishing, to conserve and enlarge upon unspoilt countryside as special reservations and to establish national parks.

Recently, however, the "subject" front of this literature has begun to broaden. The rapidly growing danger to the living conditions of present and future generations which lies in the anthropogenic remoulding of nature has become the leading emphasis in this literature. The fact is that due to the rapidly growing and uncontrolled use of natural resources, continuous and careless pollution of the atmosphere and hydrosphere and the spontaneous remoulding of the environment mainly through its devastation, mankind has already overstepped the threshold of nature's self-defence. Mankind has encountered the direct threat of the total exhaustion of natural resources in different parts of the world. It has also encountered a sharp worsening in the environment and the appearance of properties and substances dangerous and even disastrous to all living beings. Regressive signs in the biological evolution of man himself are also appearing owing to a serious disturbance of his natural genefund.

Naturally questions arise concerning the reasons behind the appearance of such a powerful flow of modern literature and the great impact of this literature on world public consciousness. As has already been said above we are discussing problems which touch directly upon the domestic, physical, cultural and, to a certain extent, the moral interests and requirements of every individual and mankind as a whole. But it is the sheer importance of these problems that can lead to their exaggeration, or even to the deliberate distortion of their subject-matter and scientific significance for political ends. The reason for the latter is that in admitting and even stressing that the common responsibility of all mankind for the unreasonable plunder of natural resources lies in the past, some people still try to reject the especially negative role of the capitalist system. But this is exactly what the Marxist classics put forward long before. It is possible to say, however, that at present the problem of "Man and Environment" is moving to the centre of the stage of world public opinion, ranking with such contemporary cardinal problems as atomic energy and space exploration.

Indeed, it may be recalled that as far back as 1968 the United Nations Educational, Scientific and Cultural Organization (UNESCO) held a special intergovernmental Conference of experts on the scientific principles of the rational use and conservation of the natural resources of the biosphere. The results of this Conference are closely related to a number of important proposals on the environment which are being given high level consideration at present by international organizations.

They include, for instance, the proposal to organize research work in the near future in accordance with the international programme "Man and Biosphere" devoted to the scientific, technical and educational aspects of the problems concerning the rational use and conservation of the natural resources of the biosphere and the improvement of the environment (20th Recommendation of the Conference). At present extensive preliminary work is being carried out.

Before the UNESCO Conference, the Swedish Government put forward a proposal for holding a special UN Conference on "Man and Environment" at a meeting of the UN Economic and Social Council (ECOSOC). This proposal was adopted by the ECOSOC, seconded by UNESCO and ratified at the XXII General Assembly of the United Nations. This international conference will be held in Stockholm, Sweden, in 1972. One of the results of the Conference should be the adoption of a Declaration on the Human Environment.

Thus, in the near future scientific organizations will have to take part in a number of important international actions. They will be directed towards a comprehensive analysis of the present conditions of the environment, the definition of tasks and procedures of subsequent scientific investigations, as well as the elaboration of the main political and practical proposals concerning these problems at a national and international scale. Naturally, the question arises — to what extent is present science ready to fulfil these tasks?

In order to answer this question it is necessary to dwell on the modern scientific aspect of the problem "Man and Environment". For this purpose the world-wide recognition of a single scientific conception of the biosphere is indispensable.

Indeed, it becomes quite clear that under the conditions of economic progress the brilliant foresight of V. I. Vernadsky — a prominent Soviet scientist — on the transformation of the environment, i.e. the *biosphere* to a new state which he called the *noosphere* is becoming true. It should be remembered that according to V. I. Vernadsky the noosphere is a new geological phenomenon on our planet. For the first time man has become a large-scale transforming force at the global (geological) scale. The planet's appearance changes ever more radically under man's influence. The chemical composition of the biosphere changes only gradually, tough in a certain direction. The Earth's atmosphere and its natural waters undergo change both physically and chemically. Man creates new species and distributions of animals and plants. He forms consciously and spontaneously a new environment for himself both by transforming its former properties and by creating new ones.

It seems that it is this remarkable foresight of V. I. Vernadsky — on the transformation of the biosphere to the qualitatively new formation of the noosphere — that represents the most universal definition of the scientific problem of "Man and Environment".

Arriving at this conclusion on the basis of the analysis of the scientific literature on the problems of the environment it is necessary, however, to stress that the front along which the scientific investigations of these problems are at present being carried out does not accord with their actuality. This front is extremely irregular, for side by side with advanced studies it has many retarded areas and deficiencies. In general, specialized investigations are closely connected with the solution of actual practical tasks. The weakest links are general theoretical and research work which should plot new ways of rationally utilizing natural resources, effective conservation and improvement of the environment under present conditions and future scientific and technical progress. The results of such investigations may quite often come into conflict with common practice in the use of natural resources and may therefore not always enjoy the necessary support.

Such a situation, however, will undoubtedly change under the quotidian demands of life and the impact of public opinion. Therefore it is very important to forecast the main orientations of scientific investigation which will constitute the modern front of research work. In our opinion these trends are the following:

(1) The development of scientific forecasting of the natural resource requirements of society in the future. Further prospecting for, and the economic evaluation of these resources is also necessary.

(2) The study of natural environmental hazards and the development of the means of forecasting and active prevention.

(3) The development of a scientific basis for the prevention of and measures against the pollution of the environment, as well as change of its composition in a direction unfavourable to mankind.

(4) The transformation of the environment providing for a rational use of natural resources and the distribution of social production, and the weakening and elimination of the negative consequences of society's influence upon the environment.

(5) The protection of the environment with a view to future scientific investigations.

All the aforementioned trends in research are vital.

Forecasting in natural resource studies is dictated by the necessity of a complete transition from a spontaneous to a planned use of these resources.

It must be based on the extent of reserves, natural renewal and the consequences that occur when resources are being removed from the environment. Only such a scientific approach to the exploitation of natural resources will help mankind to prevent or at least soften resource deficiencies and environmental crises, which already occur and threaten to increase in number. Examples are a deficiency of fresh water in a number of industrial regions and the processes of anthropogenic erosion and deflation developing on cultivated land.

It is perfectly clear that the scientific forecasting of future natural resource requirements is a complicated task. Forecasts should be derived from a system of initial forecasts covering the problems of population growth, the definition of society's future material and cultural requirements, and prognoses of general scientific and technical progress. Thus, this scientific work should be considered a part of or a linkage within a whole chain of futurologic developments.

The study of natural hazards — for instance, drought, floods, earthquakes, snow-avalanches, land-slides — together with their forecasting, prevention and methods of protection have always been of vital importance for mankind. These phenomena have long been studied and some success has been attained especially in actively influencing separate phenomena (for instance, hail prevention and fog dissipation). However, although we have learned how to overcome elementary forces, we cannot always forecast them with certainty. Nevertheless, it is perfectly clear that at present the total damage to mankind from the elements is constantly increasing. It is doubtful whether this is to be explained by increases in their intensity and frequency. On the contrary, it is simply that mankind is becoming more sensitive to such phenomena and damage caused by them.

The danger from the increasing pollution of the environment, causing a variety of disastrous results, is the key subject in current literature on the problem of "Man and Environment". The man-environment system has many aspects and it is not possible to consider them all. Therefore only one aspect will be stressed, namely, the necessity to obtain valuable and reliable information for tackling the problem in the future. The first important task lies in systematically estimating the actual toxicity rates of the most common industrial effluents, the pesticides used in agriculture and the refuse from large cities as they effect different living organisms under different geographical conditions. The second important task consists of organizing a system for the collection of coded information and control over the rate of air pollution, and water and soil contamination. And finally, the third task lies in systematically investigating potential "self-cleaning processes" which are found in various natural mechanisms, as well as an estimation of the maximum load which they are able to sustain.

But apart from these three important tasks, the development of geophysical, geochemical and biological investigations on planned environmental change under the influence of long term economic activity should be carried out. For instance, the problem of overheating the environment due to heat released when burning mineral fuel (fossil fuels); the change in the radiation balance of the earth's surface due to the extensive pollution of the atmosphere and changes in its composition through the increase in CO_2 content. Such geochemical studies start with the problem of the general increase in various radio-active substances in the biosphere and in living organisms and end with the problems of the extensive despoilation of the earth's surface, local and widespread change in the oxygen content of reservoir water and in other environments. As all investigations are carried out on an insufficient scale at present, research work should be extended to toxic substances causing the direct poisoning of the environment along the three main trends already discussed.

The complex research work on the remoulding of the environment for the purpose of the rational exploitation of natural resources, and the weakening and elimination of society's negative influence upon the environment should constitute the main content of constructive scientific investigations. In modern science much experience has been gained in carrying out such research work, for instance, for hydropower purposes (flow control, construction of water reservoirs, and interbasin flows of river water), for carrying out extensive land reclamation work (irrigation and drainage), and afforestation. There is no doubt, however, that at present the front along which such investigations are being carried out should be expanded continuously and rapidly.

In conclusion it is necessary to say a few words about present research tasks on the protection of nature. Even the conservation of rare species of wild animals by restricting hunting and fishing is now transformed into the conservation of the environment for the purpose of recreation.

There is a great difference in the tasks when organizing an area as a nature reservation on the one hand, and a recreational zone, on the other and in both cases a new approach is called for.

Apart from the function of conserving natural genetic materials (genefunds of living plants and animals in ecosystems), reservations are a priceless bridgehead from which to carry out versatile research work on a purposeful remoulding of nature. Such research work is necessary for studying the processes of heat- and moisture-exchange in the environment, the factors of biological productivity and, in general, the features of the natural structures and mechanisms created in the environment during the geological evolution of the biosphere. The results of such research work can and must be widely used to develop methods for a purposeful, i.e. conscious, remoulding of nature by man. It is precisely this fact that makes them so urgent now.

As for the use of the environment for the purpose of recreation, this task is now becoming more than urgent. It becomes clear that in particular the city-dweller surrounds himself with many beautiful articles of material comfort and at the same time lives in such an artificial environment that it is in many respects contradictory to his biological nature. That is why having gained victory over many age-old diseases which in the past devastated many European countries, for instance, the plague and cholera and having achieved a considerable increase in the average life span, modern medicine has now encountered many new diseases, mainly of an "urban" character such as psychoses, nervous diseases and chronic disorders of the cardiovascular system.

In spite of tremendous progress of chemotherapeutics and the appearance of various drugs to cure such diseases, the citizen with the help of doctors tries to find in nature the recovery of health, overtaxed by urban surroundings. Giving way to such biological impulses the citizen rushes out on walking tours, to recreational "green" zones, and national and people's parks. There is no doubt that modern science should thoroughly work out the most effective use of areas combining favourable natural properties with features and technical devices to provide people with relaxation.

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The author would now like to put a general question. Which of the present sciences or groups of sciences is able to take major responsibility for the fruitful theoretical and practical development of the interrelated problems of the further rational exploitation of the natural resources of the Earth, and for the conservation and purposeful remoulding of the environment which are necessary for the future existence of human society?

In answering this question one is reminded of the fundamental content of the Soviet national report for the 1968 UNESCO Conference entitled: "The Resources of the Biosphere of the USSR: Scientific Fundamentals for their Rational Use and Protection."*

This book has been created by the collective efforts of many specialists, under the auspices of the Institute of Geography of the Academy of Sciences of the USSR. And this was not accidental, for in spite of many rumours about the state and tasks of the ancient science of geography in our dynamic times there is no doubt that modern geography is best equipped in terms of scientific content to analyse the problems of "Man and Environment".

This is fully in accordance with its present tasks. This belief was stated as far back as 1960 in the introductory chapter of the book "Soviet Geography: Results and Tasks" where it is stated:

"Modern geography is not a descriptive cognitive science with the main object of studying unknown countries and lands. It is a science of transformative character, its main object being the study of discovered lands and countries mastered long ago by man which are of greatly changed nature, dense population, and highly developed economy. The main task of modern geography in the whole world does not consist of rendering assistance in the pioneer development of new lands and natural resources but as a many-sided science serving the great work of mankind in the intensive and versatile use of discovered natural resources, in the transformation of nature and economy in developed lands and countries."

It is necessary to bring this general definition up to date. It is for this purpose that we have suggested that the new definition of modern geography should be *constructive geography*. By this definition we have tried to stress that modern geography, having undertaken the many-sided development of the aforementioned world problems, must develop rapidly into a science of the planned transformation and control of the environment in the interests of mankind. We believe that in the whole course of its development, geography

* At present this work is being published in the form of a book by the *Nauka* Publishers, Moscow, 1971.

has been prepared to undertake a fruitful modern research work. In its arsenal there is a large amount of scientific information on the environment, and on natural resources and their economic use. In this development geography can draw on its subdivisions and adjoining branches of science, which study the regularity of change in separate components of the environment (for instance, climate, water, soil, vegetation and the animal world), and the development of different branches of economy and population. Finally, geography possesses a synthetic (complex) approach to natural and social phenomena which is especially necessary for tackling successfully the new scientific tasks.

It is necessary to stress that the theoretical basis of constructive geography is a conception of the close relationship and interaction of all components within the geographic environment which become particularly complicated under the influence of their economic utilization. It is known that the application of technology to any of the components of the environment causes complicated chain reactions throughout the whole system. However, the presence of a definite "tolerance level" in the complicated dynamic systems which control the internal (direct and regenerative) linkages, between the various components of the environment (for example, the heat regime of the earth's surface, the water balance of an area and the biological productivity of a landscape) provides the possibility of influencing the internal linkages in order to achieve definite changes in the various components (for instance climate, water, soil, and vegetation) and to forecast them.

It is necessary to point out that we should not underestimate the difficulties which confront us in the development of a new constructive trend in geography and its transformation into a science controlling the environment. The difficulties lie in the necessity of changing from common description to quantitative analyses which are more precise and have a concrete technical and economic content. In order to achieve such characteristics it is necessary, first of all, to apply new methods of investigation and calculation with the help of the existing mathematical, physical, chemical and biological tools. In addition, it will be necessary to develop new theoretical and methodological trends of approaching the analysis of phenomena. In other words, it will be necessary to develop further not only the traditional trends of geography but to reconstruct these trends, as well as many of the traditional ways of geographical thinking.

This problem, however, is surmountable and the main role in the future progressive development of our science will belong to the younger generation of geographers. We, being representatives of an older generation, should demonstrate the perspective nature of these approaches.

GEOGRAPHERS AND THE CONTEMPORARY CONCERN OF THE ENVIRONMENT

by

K. M. CLAYTON

The last few years have witnessed a widespread social phenomenon in many industrialized countries that we may loosely term the conservation movement. A decade ago, concern for the quality of the environment around us was virtually restricted to a few ecologists and to some idealists who strove through voluntary societies to conserve, and more often to preserve features of our environment. For most of us, squalor was the inevitable accompaniment of industrial production, but it seemed possible to confine it to industrialized areas. The contrast between the palaeotechnic environment of industrialized coalfields and unspoilt hills, mountains and valleys elsewhere persisted, and attractive open space never seemed far away once the major industrial cities were left behind. In addition, most areas of agricultural land were formed in a neat way that was found attractive: indeed for many the beauty of such man-made countryside seemed greater than the rugged grandeur of the wild hills and mountains.

In quantitative terms not much has happened to destroy this view of our environment. With increased urbanization, growth of population and rising housing standards, towns have spread, converting country into suburb, village into satellite town. Factories have spread in industrial areas, rarely reusing the old sites, more commonly occupying level spaces carved out of the neighbouring countryside. Changes in agricultural techniques have led to the destruction of hedges and trees, and to ugly new farm buildings. Longer holidays, increased affluence, and above all the motor car, have increased the numbers seeking recreation in the agricultural countryside, at the coast, or in the hills. Yet for all these pressures most of our rural environment is little changed, and for those willing to walk away from the road solitude is still easily found. It is surely not the scale of these changes, but our perception of the threat they pose if unchecked, that has brought about the present concern. In particular, we seem to have learnt, at last, the ease with which environmental degradation may spread, and the difficulty and cost of reversing many of the processes involved.

Even the most superficial examination of the conservation movement in, for example, the United Kingdom, reveals a confused mixture of quasi-scientific concern and thoroughgoing sentimentality. In the U. K., at least, few geographers are involved, and the scientific element in the leadership is composed of ecologists and other natural historians. Often the initial impulse has come from a desire to protect birds or (less commonly) plants, and the widening to environmental conservation generally, may not yet be complete. It is worth noting that the same principles guided the establishment of the

Nature Conservancy which has since evolved in the same direction, although rather more slowly. It is difficult to know whether it would be best to express satisfaction that so far geographers have kept clear of this movement, or to express disappointment that they have not been more active and so headed it in a more satisfactory direction. Whatever the view of the past, it seems that it is time that geographers contributed effectively to the environmental debate, and in the rest of this paper, the arguments for participation will be put forward.

With its traditional concern with the relationship between man and his environment, geography is centrally-placed within environmental disciplines. On one side are the environmental scientists concerned with the physics, chemistry and biology of the environment, on the other hand are sociologists, psychologists and economists. At times representatives of these groups claim that they represent all, or all that matters, of environmental studies. Cost-benefit analysis may be used to compare and assess diverse aspects of environmental change, as a technique to analyse past behaviour, or to aid in a decision for the future. Chemists claim at times that pollution is chemical in nature and always may be corrected by chemical techniques. Most common of all, ecologists claim that they alone understand the proper functioning of the world, and can pronounce on the way resources should be used, claiming that a world fit for the peregrine falcon, is the only world fit for man. Finally, some geographers have attempted to extend the range of the subject to encompass all these points of view and so establish the true environmental science.

It should be obvious to all of us that the scope of the environment is so great that no one man and no one subject may encompass it. Geography is not and cannot be so comprehensive; coherent study of a subject requires some sensible limitation of its scope. Yet geographers do find themselves centrally-placed within the environmental field, and seem to be one of the few groups of trained minds able to judge ecological claims alongside those of a socio-economic character. They are able to note that ecology has not yet encompassed man, and that it is still far from clear that the relationship between organisms and environment at the individual ecosystem level is the relationship that must govern the interaction between man and the global environment. Geographers will note that social and political organization are as significant a differentiating factor as the zonal ecosystems of the world environment. They will be able to accept the necessity for finding ways of achieving control over pollution that are more fundamental and far-reaching than present attempts to deal with the problem by local legislation, so often based on not more than a hunch that this particular action is required.

Most important of all, in my view, that geographers should be able to bring a sophistication to the meaning of resources that is at present completely lacking in the approach of ecologists. Their assumption that all the world's economy must rapidly be based on recycling of all raw materials needs rational analysis. The spectre of a world using up its non-renewable resources is one that has captured popular imagination. It does at first sight seem likely that the world will run out of some of its basic raw materials. As a geographer, I am not suggesting that we have no problems; there seem many reasons for hoping that world population growth may be checked as quickly as practicable, although no one is very clear how to achieve it. But the naive approach to the concept of a resource which is displayed by many ecologists deserves attack. We do not suddenly run out of non-renewable resources. As the known reserves are exploited, and as intensification of the search for further reserves fails to find as much as we had hoped, impending scarcity brings a rise in price, a more economical use of the material, and the adoption of substitutes. As a result we never run out of anything, and unexploited reserves of marginal quality are always left unused. A glance at the lowest grade of ore mined in the world for a range of metals will show how far this process has yet to go in some cases. The time may come when we reach a level of ecological sophistication, and have an economy that is wholly based on renewable resources. It need not, and indeed should not, be reached in a hurry.

The last contribution I would hope that geographers would make is to take a global view. A survey of the world literature will first of all make it clear that pollution is a problem unrestricted in space, and characteristic of all systems, capitalist and socialist alike. There may be marginal differences between societies and it may well be that a thorough analysis of these would help in the search for the fundamental control of this problem we need. The second aspect of the global view involves the concern of members of some industrialized and developed countries to seek to limit economic growth in order to reduce the rate of environmental change. This seems a remarkably dangerous cure that could well be worse than the disease. It is in any case a cure that can only be administered to a few countries in the world and is irrelevant to most. To the Third World it is completely unacceptable. Thirdly, the global view involves both the international movement of pollutants and the need to impose controls on a uniform international basis, particularly where these impose higher costs on competing industries. Again, the geographer has a role to play in ensuring that both the physical/biological and socio-economic environmental factors are included in the evidence for a particular decision. Too often one or the other has been neglected.

GEOGRAPHY'S LESSONS FOR HUMAN SURVIVAL

by

A. VAN BURKALOW

Earliest men, few in numbers, made only the simplest demands on the earth. With each advance in technology, however, there have come new insights into the earth's mysteries and new ways both to use and to destroy her riches. Now, with our great technological power and with the present rapid growth of the world's population, we are beginning to ask ourselves how much longer this use and this damage can continue, without resulting in total destruction of both the earth environment and mankind.

It is this question with which we are here concerned, and as we consider it we shall find ourselves face to face with four common fallacies in our thinking about the earth. In our urban society many people are guilty only of the first — a growing unawareness of the earth environment and of man's ultimate dependence on it. Those who do still remember that they are supported by the earth tend to think only of its utilitarian importance to them and to neglect its inspirational values. And they expect it to continue indefinitely to yield its utilitarian resources, treating these as if they were indestructible and inexhaustible and thinking of them as separate unrelated phenomena.

Geography, more than any other discipline, presents the great fundamental truths that can set straight our thinking on these matters. It teaches us that man is part of nature, a child of Mother Earth; that the earth environment is a network of interrelated parts, mutually dependent on each other; that the earth's renewable resources can be destroyed by improper use, and that the non-renewable ones are finite in amount and can be exhausted; and that the earth offers inspirational as well as utilitarian values.

These great truths will be considered separately, but it will soon become evident that they are actually interrelated aspects of the basic problem of maintaining an earth environment that can continue to support man. The maximum number of people that can be supported at any given standard of living is of course another important part of the problem, but it will not be dealt with in this discussion.

MOTHER EARTH: MAN'S DEPENDENCE AND HIS POWER

"Mother Earth" we call her, for from her soil, water, rocks, and air come all the materials that support our bodies and build our civilizations. In recent times, however, realization of this dependence has tended to decrease.

Primitive man's small and simple demands on Mother Earth were made directly. He took from his own immediate locality the materials that would meet his own immediate needs, and he used them largely in their original form or with only simple transformation, chiefly mechanical. His was a subsistence economy, and he was fully aware of the earth origin of the resources he used.

How different the situation is in our modern industrial and commercial society, in which more and more people live in cities, far removed from nature, and in which man's technology tends to seem more important than nature's processes. With great amounts of power at their disposal, men now exploit earth resources on a large scale, often very destructively, and not just for their own use but to sell to others for profit. They can transform these resources chemically as well as mechanically, so that they lose all resemblance to their original forms, and they can transport them far from their places of origin. To the users, therefore, they seem less and less like the gifts of nature and more and more like man's own product.

And now in this age of space exploration it would seem that at last man has thrown off his age-old dependence on the earth. Let it not be forgotten, however, that the vehicles that carry men into space are made of earth materials and powered by earth fuels, and that the space-men survive only because their vehicles and their space suits provide them with a little piece of environment basically like that on earth — except for the weightlessness.

Thus, in spite of man's growing power, and his increasingly great contributions toward his own support, he still needs earth materials and earth conditions. As Goethe said of the artist, so we can say also of mankind as a whole, that he "has a twofold relation to nature; he is at once her master and her slave. He is her slave, inasmuch as he must work with earthly things. . . but he is her master, inasmuch as he subjects these earthly means to his higher intentions, and renders them subservient."*

Man's mastery over the earth, however, makes him more and more its slave. It makes him not less dependent on the earth but more so, as he draws from it increasing amounts and varieties of resources to meet the growing per capita needs of a growing population.

THE WHOLE EARTH: A WEB OF INTERRELATIONSHIPS

The degree of man's mastery over the earth is, of course, dependent on his understanding of it, and while we have made much progress in this regard there is still much work to do. One of our notable weaknesses has been our tendency to study the component parts of the earth environment, both inorganic and organic, only as separate entities, forgetting that they are parts of a larger whole, interrelated with each other in a variety of ways and on a variety of scales. Thus we have geologists, pedologists, hydrologists, climatologists, biologists, and so on, each group concerned chiefly with certain specific parts of the environment. Ecologists go further, recognizing the interrelationships that exist between organisms and their environment within

* J. W. Goethe: *Conversations with Eckermann*, April 18, 1827.

a given region, and between the different forms of life found in the region. But geographers go still further, adding the ties that exist between the various elements of the physical environment, and the environmental interactions between regions, and thinking of these environmental elements and regions as parts of a world-wide whole. For some purposes the traditional piece-meal and local approach of the other disciplines is necessary. For others, however, the geographic viewpoint is important — the awareness of the wholeness of the environment, with man as part of it, and the study of its interrelationships not only locally but also on a regional, interregional, and world-wide scale.

Differences in the scale of such environmental interrelationships are well illustrated by the Everglades National Park in southern Florida. Drought recently afflicted that area, with disastrous destruction of its unique flora and fauna. To begin with, the drought's lowering of the water surface reduced the number of alligators, and this in turn meant fewer of the water holes that are hollowed out by these largest inhabitants of the swamp. As a result there are fewer of the smaller aquatic organisms that live in the 'gator holes and that furnish food for the birds of the region, and so there are fewer birds. On the interregional basis, we find that the water level in the Everglades is determined not only by the rainfall within the region but also by the inflow of water from adjacent swampy areas to the north. And of course drought in southern Florida resulted not from any local conditions but from changes in the world-wide weather patterns.

Thus the web of interactions exists not only within the earth environment of a specific region but also between regions.

THE VULNERABLE EARTH: EXHAUSTIBLE, DESTRUCTIBLE, POLLUTABLE

These local and regional interrelationships make the earth environment a very vulnerable one, for change of just one factor may set in motion a sequence of reactions that will upset the whole system. This was the concern of Rachel Carson in *Silent Spring*, in which she pointed out that widespread use of insecticides could eliminate not only insects (the good with the bad) but also both the birds that feed on them and the plants that are pollenated by them. It is now realized that much of man's destructive effect on the environment results from such chain reactions; and even when there seems to be only a simple and direct assault on nature the probability of related effects must always be reckoned with, as a brief mention of other examples will illustrate.

Within the Everglades, for example, man has made this sort of direct attack by illegally killing large numbers of alligators to profit by the sale of their skins. Inevitably this contributes to other faunal changes, as has been described above. And inflow of water from the regions to the north has been reduced not only by the drought but also by drainage schemes developed there in support of agricultural and settlement programs.

Deforestation of a hillside offers another case of both direct and indirect damage. Where the trees have been cut down — a specific act of destruction — there are also local changes in the microclimate, in the vegetation, and in the fauna; and there is increased runoff, with resulting flooding, soil erosion, siltation, and lowering of the water table. Floods initiated in such an area may also spread far out into distant regions, as may the accompanying siltation.

The reverse of this situation is presented by the High Aswan Dam on the Nile, where trapping of sediment behind the dam means damage to other regions because of reduced siltation. The Nile floodplain no longer receives the annual accretion of mud that formerly renewed its fertility, and so fertilizers must be used. And because the river now delivers fewer nutrients into the eastern Mediterranean there are fewer fish there.

Man's destructive effect on the environment is not new, of course. Even in Neolithic time fire, often described as man's first tool, was a powerful agent of change, and it is thought that with its help primitive man caused widespread changes in the natural vegetation, turning woodlands into grasslands, with accompanying changes in fauna. Fire was used directly against the fauna too, for it helped to round up game animals and made possible large kills, even when hunting implements were still very simple. Such hunting was probably a major factor in the extinction of a number of large mammal species in late Pleistocene time; and inevitably their loss initiated other changes in the ecology, hard for us to envision at this time.

In spite of these rather impressive results, however, early man could more or less ignore his own damage to the environment. With his small numbers he did not fully occupy the earth, and so, having damaged it in one area, he could always find a new region where he could make a fresh start. With simple technology and little non-human power at his disposal he had to work hard to meet his needs, and so his per capita consumption remained small, and non-consumable goods were usually carefully saved and re-used. He used chiefly renewable resources, and because of his small numbers and his small per capita demands he did not usually exploit these more rapidly than nature renewed them. Since he changed them very little from their natural form, the waste products from their use could easily decompose, and this, together with the sparse distribution of people, prevented the development of any serious problems of waste disposal.

Today our situation has changed greatly in many ways. Because of our widespread occupance of the earth's surface and the institution of political barriers it is no longer possible to escape from the effects of our own destruction of the environment by moving on to new regions. Furthermore, our demands on earth resources have multiplied vastly, not only because there are so many more of us but also because our per capita consumption is so much greater — made possible by the greater amount of inanimate power at our disposal and encouraged by competitive advertising, planned obsolescence, and less re-use and re-cycling. Together these changes have given us a mounting problem of waste disposal. Greater demands are being made on mineral resources, which in some cases have been largely exhausted; and maintenance of renewable resources is hampered by over-exploitation. More complicated chemical processing of nature's raw materials has attacked the environment in a number of new ways. It has given us pesticides and herbicides that destroy the flora and fauna on a massive scale. It yields new types of waste products that pollute air, water, and soil and that contribute to our waste disposal problem because they are non-degradable. Plastics, for example, and many pesticides and detergents remain undecomposed indefinitely. Most of these problems are further aggravated by the growing concentrations of large numbers of people in urban regions.

In part the seriousness of our present situation reflects the increasing magnitude of man's demands on the earth, and the increasing power with which he seeks to satisfy those demands. But the effects of our actions are magnified by the very nature of the earth — the interrelatedness of its parts. As we realize this we see that the earth is not indestructible and inexhaustible, as was so long thought, but highly vulnerable to the destructive impact of man. It is a delicately balanced system that can easily be damaged, and some of its individual parts can be completely destroyed, beyond man's power to reconstruct them.

THE EARTH . . . AND THE FULLNESS THEREOF: INSPIRATIONAL AS WELL AS UTILITARIAN VALUES

Whether we are concerned about such losses or not depends on the significance we attach to the environmental factors involved. Do we consider them "resources"? Usually that term implies something of practical usefulness, such as the substances that provide food, fuels, and building materials — the visible and tangible stuff of life. And when such resources show signs of exhaustion we worry. Until recently, however, little thought was given to the accompanying destruction of other values.

For example, strip mining, operated by huge machines, has ruined the beauty as well as the productivity of large tracts of land. Spraying crops to kill insect pests and thus increase the crop yield threatens the survival of songbirds. Do the birds have value? Most people would agree that they do, but because their value cannot be measured in dollars, it is often outweighed by the known dollar value of farm crops. Cities replace the natural environment with an entirely artificial one, and from them come great concentrations of waste, with its many problems. Our landscapes are blighted with junk. Our waters are filled with debris that fouls the beaches and chemicals that kill the fish and make bathing unsafe. Pollutants in the air not only damage our own health but also kill vegetation and impoverish the scenic beauty, as when the picturesque Monterey pines of the California coast are lost in this way. In this and other ways we decrease the variety of the earth environment.

So great has such destruction of the natural environment become that we are at last waking up to a realization of what we are losing in the process of our headlong exploitation of earth's utilitarian values. Just as surely as our bodies need food and water, so do our spirits need the life-giving inspiration, the soothing and at the same time quickening influences, of undisturbed nature and all its interrelated parts. We need the refreshment that comes from beholding the beauty of a mountain landscape, the calmness and serenity of the forest, the everchanging surface of the sea, the grace and vigor of wild animals in their native habitat. These are resources just as truly as are iron ore and building stones, even though it is not as easy to express their value in dollars.

Normally we do not set out directly and purposefully to destroy these resources, but unless we take special pains to prevent it they are victims of the chain reactions that are set in motion by our exploitation of utilitarian resources. It is their interrelatedness that makes them so vulnerable. At the same time, it is to this character that a truly wild natural environment owes so much of its charm. Its plants and animals, its rivers and lakes, its hills and valleys are all parts of an interwoven whole. It is with the hope of maintaining such whole environmental systems that men are seeking, in many countries, to preserve some areas in their natural state — places where man can be "re-created" in the full and basic meaning of the word.

We have begun, therefore, to realize that we must not let the utilitarian and monetary values crowd out and destroy the esthetic, psychological, and inspirational values of the earth environment.

THE CHALLENGE FOR GEOGRAPHERS

The battle to preserve these intangible values is not yet won, however, nor have we solved the other aspects of our environmental problems. In a broad sense the work that must be done falls into two categories, and geographers must be involved in both.

In the first place, earth scientists of many kinds must work toward developing an ever fuller understanding of the earth environment, especially its interrelationships, and geographers should help to carry on this work, both by undertaking some of the basic research and by correlating the work done by others and interpreting its significance.

If the results of such investigations are to be put to use, however, they must be passed on to the general public, and for this kind of education — the second basic type of work needed — no other professional group is so well equipped as are geographers. It is their task to develop a citizenry informed on environmental matters, from whom can be elected environmentally responsible public officials. The citizenry must learn to recognize our fundamental dependence on the earth for all that supports our bodies and for much that inspires our minds and spirits, and they must begin to consider the problem of population growth in relation to the earth's carrying capacity. And especially they must recognize that the earth environment is a wonderful, beautiful, and complex system of interrelated parts, easily damaged by man's thoughtless attacks upon it.

Only by such an educational campaign, to which geographers should make major contributions, can we hope to achieve the understanding necessary for maintaining an earth environment that can provide a full, rewarding life for the bodies, minds, and spirits of its human inhabitants.

GEOSCIENCES AND ENVIRONMENTAL SCIENCE

by

G. LÜTTIG

In the following an attempt is made to give an outline of the contribution of geosciences, particularly of geology and geography in Germany, to research work referring to the environment. It is intended to give a self-description so as to inform the "man in the street" better than before of what is done for the public in this respect. There is another reason for disseminating this kind of information. It may have been President Nixon's speech at the United Nations which gave rise to the recently increasing popularity of environmental science. This caused a number of unqualified speakers to take advantage of the public interest so generated, even though geosciences have dealt with this field of activity for many decades without making a to-do about it.

A kaleidoscopic enumeration of the fields of activity demonstrates to the reader how wide is the scope of the work of geologists and scientists of related branches in environmental science.

The elucidation of the most ancient influences exerted by man on his environment — carried on mainly by the stratigraphers of the Quaternary and by the specialists of pre-history as well as by the palynologists — brings to light the historical side of environmental science. The first anthropogenic influence on nature has been determined by means of pollen analysis of sediments of Holocene age, and that through indicative settlement remnants. The research carried out on high flood loams has confirmed the influence of man on soil erosion and, thus, on the sedimentation of soil materials eroded upstream in the middle and lower courses of the respective river. For instance, in the region of the Weser River, intensive clearing of woodlands caused the accumulation of two medieval high flood loam layers. Here, in close association with pre-history, environmental geology has been practised for more than a century as a historical science.

The results of geoscientific research constitute an important basis for providing a balanced answer to the question: What is a natural modification and what is to be ascribed to man's influence? This can be demonstrated during an investigation of the filling-up process of lakes. In order to develop the best "therapy aimed at cleaning up a lake" it is absolutely necessary to know about the natural changes taking place independent of man's intervention. The geoscientific therapy which was practised on Lake Trummen in the vicinity of the City of Växjö in Southern Sweden represents an interesting example. The discharge of waste waters into the lake formed a strongly eutrophic mud layer that still supplied substances to the lake water after the discharge had stopped and consequently prevented the lake from returning to a sound state of balance. It was only the cooperation of biologists and limnogeologists that finally led to a proposal by means of which be restored to health. Similar proposals have been made for soı flat lakes in North-Western Germany, which have recently b very quickly. A knowledge of the development of river vall important for dimensioning protection measures against high

Some geological bodies and geomorphological facts can be outright factors influencing the environment. This applies, for ir area of distribution of rocks of the Middle Keuperian, in which saline and sulphate-containing water can be obtained. In ce of Western Germany this resulted in considerable damage to he ıe end of World War II, when resettlement of refugees took place. context areas with outcropping geological structures that are serioı endangered by slipping, may be referred to e.g., the well-known Zanclod n marls in the area of the City of Stuttgart, which pose considerable problems in connection with the construction of buildings.

There are Alpine regions that are endangered by landslides and avalanches, areas of deformation that are still in motion, peat beds that are concealed beneath sands and barely able to support load, areas of Permian salt layers with dolines and subsidences. The geological map tracing out these bodies constitutes, like the soil and the morphological map, an important means of identifying the aspects of natural space to be understood as environmental factors for man.

Among the public education activities of the geoscientist the protection of natural phenomena, and thus geological phenomena, should not be neglected. A few notable geoscientific phenomena and sites already enjoy protection but there are many more in need of preservation.

Considerable importance is to be attributed to the anthropogenic influences menacing our soils. This not only refers to complex questions arising from the use of pesticides and insecticides, but also to the problems of lead poisoning, asbestosis in the proximity of roads, and finally denudation and erosion of soil. The application of great quantities of fertilizers has definite consequences on the quality of near-surface groundwaters, for instance, in farming areas with light sandy soils. A consequence of the application of salpetre fertilizers is to raise considerably the nitrate and nitrite content of the groundwater. It is to be expected that such areas that are important for groundwater supply will necessarily have to be kept free of agricultural exploitation. On the whole fertilizing has already replaced manuring to such an extent that faeces have been termed a sort of unidirectional product. Certain cases, that is large hatcheries and fatstock poultry farms, are known where the disposal of faeces cannot be solved by utilizing them as manure.

Intensification of research is necessary with regard to methods of detection of noxious matters in the air, water and soil. Geochemistry and geophysics are expected to develop a spectrum of methods that can be applied by environmental scientists for detecting and locating dangerous concentrations.

In general it is the influence on, and the destruction of the environment by the extraction and processing of mineral raw materials which are the subject to public discussion. It is a well-known fact that there are many abandoned gravel pits and quarry faces which "ornament" the landscape. In the

cases this can be attributed to the fact that the firms concerned
grade deposits, or parts of such deposits, and went out of business
the unfavourable conditions for economic exploitation. Contrary
e firmly based enterprises are able to bring about, small compa-
in a position to restore the natural landscape. Correspondingly
ulations are being prepared requiring the cooperation of geo-
xploitation is not to be allowed in areas where the profitable
earth's natural resources is precluded right from the start. The
interested companies shall be drawn to good deposits, so that
pr[illegible] rations will be ensured; and the firms will be in the position to
resto[illegible] e appropriately and to recultivate the landscape around the
pits aft[illegible] y have been abandoned.

Public o[illegible]on fails to appreciate completely that it is the deposits, too, that require protection as environmental factors. Very often the population's supply of mineral raw materials is not guaranteed in perpetuity. Mineral raw materials represent as much part of the environmental heritage as landscape and vegetation units vested with great importance for the maintenance of public health.

The most valuable environmental resource is doubtlessly represented by groundwater. Measures to be taken for its protection require a considerable support from geosciences, as the connection between surface water and groundwater can only be studied on a geoscientific basis. As concerns the spring areas and reservoirs in fairly large catchment areas, the geologist's pertinent advice constitutes the basis of the determination of the size and extent of areas for protection. The exploration of groundwater resources can only be conducted expertly by hydrogeologists. Research is being carried out on the after-effects of waste disposal of oil residues, of mine dumps, of fertilizing with biocides, of cavernor mineshaft-disposal liquid refuse, of soil compaction on the replenishment of aquifers and groundwater quality in close cooperation between geologists, hydrologists, limnologists, geochemists, bacteriologists, hygienists, pedologists and farm scientists all working in close cooperation with each other.

Important hydrochemical problems in that particular branch of science dealing with groundwater occur wherever salt-bearing rocks or saline surface waters come into contact with groundwater. This is important for all water works supplying household and industrial needs and likewise applies to cooling-water. But it also concerns those rivers that are heavily fraught with saline waste such as the River Weser, from which, for the time being, part of the household supply of the City of Bremen is obtained, and the so-called salting of coastal aquifers, that is the coastal region, where the heavier sea-water underlies the "sweeter" groundwater. Whether or not the installation of sea-water desalination plant should be propagated in this region, must be considered. The task to be accomplished consists of determining the economic relationship of groundwater exploration in the hinterland compared with the coastal region proper, which, in principle, receives an affirmative answer from the geologists of North-Western Germany.

During the last few years geoscientists have made endeavours to find new possibilities of waste disposal. This not only relates to the great number of proposals for laying out dumping sites, but also concerns sewage sludge disposal and the storage of residual radioactive by-products and bulk goods, in the underground salt dome caverns of North-Western Germany for instance. Here the basic plans were elaborated by scientists of the Geological Survey.

However, geological structures such as salt domes must not be exclusively reserved for storage purposes. After all not only is industry interested in disposing of its refuse and waste safely in salt domes, but also in extracting salt by solution mining or by conventional underground mining. There can be no competent consideration of competing interests without the advice of geologists.

The daily newspapers report frequently of oil contamination of the sea, of fish dying from waste and refuse by-products, and of the unpleasant after-effects of river discharge loaded with waste on marine life. Hydrologists and geologists are compelled to research into marine environment in particular because the extraction of raw materials from the bottom of the sea has to be expected. Expert advice is required on the extraction of sand and gravel as interference with sedimentary conditions may induce far-reaching changes in the entire biotope.

Finally, mention must be made of that aspect of geosciences concerned with road construction methods that are safe from the environmental point of view. In this connection it is necessary not only to stress the necessity of building adequate foundations on surfaces with low load capacities, but also the problem of the damaging effect of smoke, exhaust, and flue gases on building materials.

If the petrographic characteristics of rocks and their mechanical behaviour as building material are known, important advice can be given. This refers not only to ancient buildings and monuments of great historical value, but also to modern industrial and domestic architecture.

Part of this complex of questions is the problem of how to make safe man's other modifications of the environment such as barrier dikes, unembanked accretions of alluvial land, koogs and polders. This introduces the final problem of how to protect man himself against the hardships of the environment. Among other things, the question of forecasting the evolution of the climate of our planet has to be raised in this context such as for instance the problem of whether or not we are approaching a new glacial period, how we can feed the increasing population of our planet and how we can procure the enormous amount of water needed in future.

The conclusion necessarily to be drawn from this catalogue is that in public opinion geoscientific environmental research should rank first. Environmental science that does not include the geosciences is simply not possible. It is indispensable that geoscientific experts belonging, for instance, to such institutes as the Geological Surveys of the various countries be appointed to and incorporated into the numerous authoritative bodies of institutions which are now being constituted and which devote themselves to environmental science.

FUTURISM: THE NEWEST STAGE IN GEOGRAPHICAL IMAGINATION

by

P. H. NASH

Processes of change challenge human institutions and the human beings that have developed and operate them. Some of these changes are so potent that men and their activities must adapt rapidly or perish. Most societies on this planet face such crises, perhaps more severe than any in the history of mankind. Of all man-made sources of change, the most explosive are the products of modern science and technology. The past is littered with the wreckage of inflexible institutions that new methods and techniques have challenged, disrupted, and frequently destroyed. The medieval castle was rendered useless by the cannon. The craft guild was made obsolete by the factory system. The family farm was all but replaced by industrialized agriculture. The general practitioner yields to medical specialists who can keep pace better with the vast increase of knowledge. The xerox machine erodes the sanctity of personal authorship. The credit card threatens currency and personal banking. New methods of birth control alter established sexual mores. Nothing is impervious to technological change. The science of geography, the object of our fond scholarly attention, is obviously no exception!

Increasing systematic thought is being given by geographers to the concept of change. In North America, the apocalyptic viewpoint is particularly fashionable right now among many students and some faculty members. They say that they sense "in their blood" that the world is going to end. As a geographer I find this disturbing, because such a calamity would deprive me of my subject of investigation. But the various horrors described, whether ecologically, megatonically, genetically, or otherwise are not too persuasive. You and I are certain that the world is not going to end. Rather, it will go on ending, and some of the unsatisfactory realities of our existence will continue eroding our universe for endless eons to come. We cannot abdicate responsibility. In our shimmering junk heap of inherited culture and political context we treasure the transcendent values of the past, in addition to our intimate knowledge of deserts, drumlins, doldrums, DDT, dunes, dolines, drought, and disease. But we must also assimilate, with reason, discrimination, and taste, the insights of drugs, Dylan, dada, Doxiadis, Darwin, Drucker, Dror, Dante and Dansereau.

It is not enough for us, as geographers, to observe and describe these overwhelming changes. We must become a part of them, and, in turn, change the institution of geographical learning and research. And as I contemplate and review my own relationship to institutionalized geography, I discern specific stages of involvement in my discipline. This period, for me, spans three decades. In the forties, as a young geologist, I became geographized. After the war, and during the fifties, I became planningized, and then developmentized, culminating in the establishment of the first Department of Geography and Regional Planning at the University of Cincinnati in 1959. In the sixties I became environmentalized, ending that decade by coming to the University of Waterloo in Canada to head up a Division of Environmental Studies, a faculty which contains a School of Architecture, a School of Urban and Regional Planning, a Department of Man-Environment Studies, and, of course, a Department of Geography. And now what happens? I am becoming futurized, because I am convinced that focusing on the environment alone may make the geographic profession eventually sterile. Massive pressures we must comprehend, pushed by burgeoning populations and expectations, by "exploding" (?) technologies, are distorting and destroying the working arrangements of our societies and lives. The preemptory challenge is to rework these arrangements to provide environments we can endure and maybe even enjoy.

I believe, fellow geographers, that we have to recognize *three* phenomena involving our concerns, which did not become apparent until the third part of our century.

I. *The old "star system" is no longer valid*

The heroic days of the Vidal de la Blaches, the Humboldts, the Sauers, the Griffith Taylors, the Finch & Trewarthas, the Raoul Blanchards, the Trolls, the Colbys, and even the Bill Garrisons are gone. Even Brian Berry is aware of that ! Passé is the "supreme triumph" of the individual. No more Einsteins, Marx, Freud. Individuality has gone as far as it can go. The future man of genius is the genius of collective man. Any geographic heroes we may have will be anti-heroes, disposable heroes, or collective heroes.

II. *Geographers will have to comprehend "Change in Change"*

The instincts of one generation become the ideas of the next. We are failing to comprehend complex issues, and we must adapt to complex systems thinking. We can no longer "let things happen" and then look into it. "Investigating consequences" of phenomena is not enough ! We cannot divorce ourselves from happenings. And there is an acceleration of change in geography from the periphery to the center. "Thank God", some of my geographer colleagues say, "I won't live long enough to see that". But I believe that the MD's of the future will see to it that we do ! And yet, my friends, polarization will not be necessary. It is a new Copernican Revolution.

III. *Geography will be strongly affected by enormous and intimate explorations*

The world of the middle dimensions is no longer as important as we thought it was. By "enormous" I refer to explorations of the macrocosm, the universe. By "intimate" I refer to the microcosm, genetics, and the bedroom. We have few models of what we believe we should be. We also know that nothing we design should be total !

Thus you can see why I believe that "futurism" can be a broad umbrella and that geographers must learn to be comfortable under it. The significance of this approach was brought home to me at the First General Assembly of the World Future Society in Washington, D. C. two months ago, where the "Dimensions of the Future" were discussed in terms of imaginations, anticipations, and expectations. I saw only three geographers at that international meeting, and yet I am sure that they would have had much to contribute in discussions of forecasting, goals and values, public services, technology assessment, policy formulation, social indicators, the politics of means, life support systems, etc. By definition "utopia" is nowhere and thus of no geographical concern. But we should give thought to "entopia", the world of the possible, and apply our geographical expertise to assist in shaping the future. *The future just ain't what it used to be.* Reich's "Consciousness III" is OK as long as everybody is in it, but we still live in a Kafkaesque world. As geographers we must remember that the worst thing that can happen to a parasite is that it finds a perfect host!

And this brings me to express an important concern, namely the widespread conviction on behalf of many geographers that we can avert catastrophe only by achieving a *steady-state environment*, where all forces acting upon it, internal as well as external, cancel out. Such examples as the equilibrium phase of chemical reactions, the homeostatic mechanism of the human body, the equilibrium state of statistical mechanics, and the "balance of nature" are ill-advised. To counter these arguments a simple word suffices: Pleistocene. True, on some occasions man has achieved a truly steady-state environment. Such scattered primitive societies as the Eskimos, South Sea islanders, Australian aborigines, nomadic tribes in Asia and North Africa are examples. Perhaps the closest approach to a steady-state environment relationship by a large, highly cultured, and technologically advanced society was that of the Chinese Han people who occupied the North China Plain. But in spite of the fact that DDT has spread over the entire globe, it is a fact that within one year of the introduction of DDT into Ceylon the human death rate there declined forty percent.

What so deeply disturbs me about the alleged validity of the concept of the goal of a steady-state environment is that there is a built-in conflict between freedom and environmental compatibility. The more precisely man achieves compatibility with his fundament, the more constrained and ordered his behaviour is likely to be. The achievement of perfect compatibility is the negation of freedom. However, when the incompatibility of man with his habitat generates stresses too severe, freedom is also lost owing to the malfunctioning of the whole system. Thus we have a mandate to set our goals somewhere between the technological dictatorship of flawless, accident-free behaviour and the bloody and catastrophic freedom of irresponsibility. And it is my conviction that the geographer can and should make major contributions to identify irreversible trends towards catastrophic incompatibility.

Think of the following potential technological developments, their impact on their environment, their geographical influences, and their potential source for exciting scholarly research:

(1) Operation of the first thermonuclear (fusion) electrical power plant. (Cheap and clean power.)

(2) Widespread (greater than 10% of the labor force) corporate employment of people working at home, enabled by significant improvements in communications and control networks.

(3) Development of economical fertility control agents which can be administered on a mass basis through techniques such as seeding of water supplies or in food production.

(4) Substantial increase (by a factor of 2 or more) in agricultural production, through a combination of techniques, which raise the world's economically arable acreage, and of developments in plant genetics which enhance productivity per acre.

(5) Feasibility of limited weather control in the sense of predictability affecting regional weather at acceptable costs.

(6) Availability of cheap non-narcotic drugs (other than alcohol) which produce specific and predictable changes in personality characteristics, such as reduced anxiety or aggressiveness.

(7) The construction of at least 10 major cities under the earth or on the ocean floor for populations greater than 25,000.

(8) Availability of a computer which comprehends standard I. Q. tests and scores above 150 (where "comprehend" is to be interpreted behaviouristically as the ability to respond to questions).

(9) Major cities of the world tied together by high speed vehicles (greater than 200 miles an hour).

(10) Feasibility of using drugs (as opposed to dietary supplements) to raise the level of intelligence in persons (not just temporarily raise the level of apperception).

(11) Demonstration of chemical control of the aging process, permitting extension of the average life span by 50 years, with commensurate increase in the number of years of vigor.

(12) Feasibility (not necessarily acceptance) of chemical control over some hereditary defects by modification of genes through molecular engineering.

I believe that these examples suffice to indicate my conviction that it is essential that some geographers in many parts of the world get "futurized" with deliberate speed.

According to a recent North American survey, 1,600 advertising messages are directed to each individual person daily. He becomes conscious of 80, and responds to 12. The conclusion was that "we survive", only because we have learned to "screen out!" Fellow geographers, let us also learn to "screen in", develop more *imagination*, so that we can invent better futures. Could we contemplate General Electric or General Motors without a profit motive? Let us not shun, what Robert Jungk calls "Gedankenspiele". They moved earlier geographers to expeditions and explorations. Modern scholars concerned with the total environment need not confine themselves to the world of visible middle dimensions. Let us use an imaginative and heterogenistic approach, not culture-bound, not ethnocentric. We must play more with imaginable alternatives and utilize spiritually intuitive capacities.

Although a somewhat simplistic approach, we can adopt from professional planners the perspective that future environments will consist of four basic ingredients: the physical fundament, the declining human past, the continuing human past, and the created future. Geographers are thoroughly familiar with the physical fundament of our planet, which can be expected to remain reasonably constant for generations to come. We can consider ourselves the declining past, because we are mortal. The continuing past will be our children and their children, and our continuing impacts, both physical and cultural, on the landscape. However, with intellectual and moral courage, and with full utilization of our problem-solving capacities, we can progress with imaginative conceptualizations of the created future, and the concomitant impacts on our environment. It is a challenge for our creative efforts, strengthened via geographical scholarship, to focus our imaginative resources on alternative future environments.

GEOGRAPHY AND THE FUTURE UTILIZATION OF NATURAL RESOURCES

by

I. V. KOMAR

Various aspects of the utilization of natural resources have long been investigated by scientists of different specialisms, among whom geographers have played a considerable role. In the modern world the problem of exploiting Nature's resources exhibits significant new features. This is due to the intensive socio-economic transformations taking place on this Planet, to the revolution in science and technology, to Earth's rapid population growth and to the rise in the material and cultural demands of mankind including the mass of peoples in the ex-colonial and semi-colonial countries of Asia, Africa and Latin America.

Attention is focussed nowadays on questions concerning the natural resource needs of Earth's population and the associated tasks of conserving and improving the quality and integrity of the natural environment — the habitat of Man. To solve these problems increasingly efficient means of exploiting natural resources are being used. Hence the special need for long-term prognoses.

The drafting of prognoses of this kind has recently become wide-spread. The complexity and keenness of supplying the Earth's growing population as well as the pronounced social and political aspects of this problem have given rise to most various and sometimes even diametrically opposed views concerning the essence and means of solving it in the long run. Existing prognoses can be divided into two groups. One includes entirely pessimistic approaches to the future, seeking to verify the fatal incongruity between the increasing resource demands of mankind and the possibilities provided by the natural environment. In their most extreme expression such prognoses foretell of the death of human civilization, and urge measures to reduce the population of the Earth by such means as genocide, forced sterilization of "defective" people, and just destructive wars.

The opposing group of prognoses is characterized by optimism concerning the resource problem of mankind, though the difficulties of any radical solution are not denied. This group of prognoses relies on the further development of science and technology and on the resulting socio-economic progress creating the prerequisites for the rational direction of the interaction between society and nature. It can be hardly doubted that the basic principles of this second group of prognoses have been adopted by progressive-minded geographers around the world.

It seems essential to point out in this paper that geographers in many countries of the world do not yet sufficiently participate in developing universal, long-term forecasts of the utilization of natural resources according to the afore-mentioned principles.

Prognoses of this kind are usually drafted by sociologists, economists, demographers, ecologists and specialists in many other branches of knowledge, with geographers being involved least of all.

Geographers are insufficiently represented at relevant international meetings, though the problem of keeping pace with the increasing resource demands of mankind without impairing the natural environment is intrinsically a geographical one.

Amongst the most important features providing the geographical sciences with a high potential for investigating this problem, at least three can be listed. Firstly due to the complex nature of the phenomena under study, the interdisciplinary character and the synthetic approach of geography is eminently suited to their investigation. This facilitates the application of modern methods of system analysis in developing prognoses as widely as possible. The present writer is convinced that one of the main defects of long-term resource supply forecasts is of the lack of a well-harmonized approach to this many-sided problem. Prognoses of this kind are frequently characterized by the prevalence of one-sided demographic approaches, relying on abstract biological laws in most cases, or by a purely scientific-technological outlook which underestimates the role of social processes, or by strictly economic considerations which disregard many important regularities in the functioning and evolution of the natural environment. Restricting oneself to analysing biosphere processes and to the use of biological resources only cannot be approved of either.

Not denying the actuality of the problems concerning the demand of the Earth's population for biosphere resources, let us remember that people now seek to extract more resources from a wider domain of nature including the deep-seated strata of the earth's crust, and the high altitudes of the atmosphere. Accordingly, to satisfy man's needs for natural resources one has to study the relevant potentials of the entire geographical environment and, at the same time, take into consideration the necessity of continuously widening its spatial domain beyond both the limits of the biosphere, and the envelope of the Earth's surface.

As early as the first half of this century, academician V. I. Vernadsky defined the geographical environment as being confined to the dynamic limits of the so-called "noosphere" or to those aspects of nature effected by the activities of human society. In the 1960s Professor M. M. Ermolaev, in developing further this theory and studying Man's energy supply, formulated the term "geographical space" as extending from the upper boundary of the atmosphere to the earth's crust (zones of hypergenesis) or, in other words, to the upper mantle.

It is evident that the scientific synthesis of such diversified aspects for satisfying the natural resource demands of mankind should be compiled in closest collaboration with specialists of many other branches of knowledge. In the final analysis, the role of the geographer should be that of synthetiser and coordinator of interdisciplinary investigations into the problem.

Another feature of geography enhancing its importance in making long-term prognoses for the utilization of natural resources and satisfying Man's needs lies in its concern for the interaction of nature and society. The conversion of geography into a system of interrelated disciplines will lead to geographers' drafting detailed long-term prognoses for single types of natural resource and for various components of the geographical environment modified by Man during their use. In this case the geographer will act as one of many specialized participants but at the same time will preserve a synthetizing function thanks to his geographical training.

It should be underlined that "partial prognoses" of this kind are already being drafted by geographers (e.g. forecasts concerning the fresh water budget, and the utilization of climatic resources and solar energy resources)

Another very important feature of geography is the regional-spatial aspect of analysis. It is difficult to overestimate the significance of this feature of geography in studying the general problem of satisfying the resource demand of mankind, considering the diversity of socio-economic, productive technological, historical, natural and ethnographic conditions, in the various countries and regions of the world.

Geographers already have a great deal of experience in elaborating tangible regional problems of natural resource utilization. Similar geographical investigations in individual countries and regions should be developed in the future, as well. The immediate task is to promote this work to the level of long-term prognoses and to take into consideration the universal problems of both natural resource supply and natural environment preservation. This again implies to participate widely in both the theoretical and practical aspects of these general problems. The close ties between fundamental and applied geographical research are manifested most clearly here.

That there are objective possibilities of satisfying the raw material and energy demands of mankind in a reasonably time perspective can already be stated. As shown by available estimates, many of the most important non-renewable natural resources can satisfy the growing demand for many hundreds and even thousands of years. Renewable natural resources can supply a population many times larger than the present. The resources under consideration are those which are utilizable and exploitable under existing or predictable technologies. It is important to emphasize that technological progress renders possible interregional transfers of natural resources (water, fuels, ores, etc.) and the substitution of a depleted resource by another one. Let us quote, as an example, the calculations concerning energy supply. If the total demand for energy doubles during the next 20 to 100 years, known energy resources will be sufficient for a further 2,500 to 12,000 years (in the calculations both traditional and new energy resources including nuclear fuel, and tidal energy have been considered). Wide possibilities exist for the better utilization of the energy resources already being exploited, as use efficiency accounts for hardly more than 10 to 15 per cent of the total extracted reserves of the fuel deposits under exploitation. Low utilization efficiency is also characteristic of food resources (including agricultural products), when losses during all phases of production are taken into account, many of which could be eliminated even under existing techniques.

The importance of taking into account and recognizing the social aspects of natural resource prognoses is clear. Let us quote the problem of nature conservation and of coordinating measures to reduce expenditure on armaments, to eliminate the remnants of colonialism, and to remove artificial obstacles to the international exchange of energy resources, raw materials and semi-finished products. These questions imply in the long run the existence of a suitable balance between accumulation and consumption, a point of particular importance for the developing countries.

Similar situations arise in respect of conserving the necessary qualities and properties of the natural environment during resource utilization. These questions have already been considered by Prof. A. A. Mintz, and need not be discussed here. Let us only remind ourselves of the increasing gravity of the situation due to air and water pollution, to soil erosion and to difficulties in preserving the normal functioning and development of the whole biosphere.

The widening participation of geographers in drafting long-term natural resource prognoses and the simultaneous conservation and improvement of the natural environment will enhance both the comprehension of the essence of this problem, and the development of new methods of relevant investigation.

Some of the methodological approaches used by the author while studying individual aspects of the problem will now be enlarged upon. One important aspect is the determination of natural resources demand and the rates of extracting required substances from the environment.

To this end, the dynamics and structure of the exploitation and consumption of natural resources in the USSR during the period 1913—1960 were analysed and estimates made of consumption over the next 15 to 20 years. The data of the USA were processed similarly and the prognoses made for the American economy by the well-known corporation "Resources in America's Future" were adopted for the determination of potential demand in that country.

The material for the USSR demonstrates a rapid increase in the gross consumption of natural resources, the per capita consumption being 4·9 tons in 1913, 7·4 tons in 1940 and 14·3 tons in 1960. In addition, the rate of increase in consumption, in terms of total weight, is accelerating. A less clear picture is obtained for the USA, for although the consumption of raw materials (home and imported production) increases, the curve of increase is less steep and less steady. As shown by the resulting dynamic sets, there are striking relationships between variations in gross consumption of resources and the growth in national gross production. In addition, the gross consumption of natural resources was observed to rise in response to a given increase in national production. Accordingly, in the USA this increase was estimated to have attained 72 per cent during the years 1940—1960 and 99 per cent between 1966 and 1980 (in USSR 49 per cent and 70 to 80 per cent, respectively).

The consumption of the different types of natural resource does not change uniformly. The consumption of extractive products increases rather more rapidly than of agricultural produce. Rates of increase are particularly high in the case of energy resources, some types of ore and a number of nonmetalliferous minerals.

It seems that a study of the dynamics and structure of the production and consumption of natural resources in the above-outlined way in all countries might provide useful information. This would, in turn, help unravel the major dynamic and structural trends in world-wide natural resource exploitation and help identify the most important regional variants in these trends. A suggestion of this kind was already made by the writer in his contribution to the XXI Congress of the International Geographical Union in New Delhi (1968).

The results of comparative studies concerning the dynamics and structure of the utilization of natural resources in the USSR and USA have been discussed in more detail in a number of the writer's publications including a two-volume work devoted to the jubilee of the former President of the Commission on Applied Geography, the late Prof. O. Tulipe.

Let us recall that in those works the following major groups of natural resource can be recognized: mineral fuels, black metal ores, non-metalliferous minerals, wood, agricultural produce and natural fodder resources. It is evident that this list has still to be widened, to include such resources as the air of the atmosphere and water whose consumption exceeds all the afore-listed resources by one or more orders of magnitude (i.e. more than 10 to 100 times).

Subsequent investigation of the problems concerning long-term prognoses of natural resource supply showed the usefulness of the application of the so-called resource cycle.

The fundamental principles of this method are as follows. Since prehistoric time the Earth has witnessed gradual changes in the circulation of materials, a process connected with the consumption of energy in various forms. The appearance of Man resulted in a specific social link in this general circulation system, e.g. the exchange of materials (and energy) from nature to society and back to nature. To date, the importance of this linkage has increased and its structure has become extremely complicated.

The driving force of the exchange between society and nature is labour, i.e. social production. This is the medium through which Man mediates, regulates and checks the process in varying measures depending in the first place on the socio-economic structure of society. Since exchanges within the "nature-society-nature" cycle have to repeat themselves constantly, social production should also be considered a continuous process of reproduction. This means that both the gross production of society and the return of utilized materials (and energy) to nature should under certain conditions be included in the analysis. In other words, a geographical analysis of all stages of the exchange process within the "nature-society-nature" cycle, inclusive of the direct biological exchange of materials between man and the environment, is necessary. At the same time, changes in the general circulation of materials on the Earth under the influence of this process should be taken into account.

Accordingly, the resource cycle is understood as the sum total of transformations and displacements of natural materials (or group of materials) in the course of being utilized by Man. These include extraction, processing, consumption and their return to nature and belong to the social linkage within the general circulation of materials. At a first approximation, six resource cycles and a series of subcycles can be distinguished: energy resources (I), ore resources (II), non-metalliferous minerals (III), forest resources (IV), soil, climatic and agricultural resources (V), and wild fauna and flora (VI).

The resource cycles not only differ in the type of main material utilized, but also in the character of the accessory natural materials involved in the circulation, in their duration, in the development of specific branches, and in the form of "intra-social" circulation, especially in the various kinds of secondary raw materials. The specifics of resource cycles utilizing renewable resources (e.g. soil and vegetation) is of particular importance. These include the recreation of such resources and the processes taking place in nature under human intervention (afforestation and agricultural production).

In reality, resource cycles do not function in isolation but are closely connected with one another through a maze of mutual linkages. Therefore the polycyclic nature of the interaction of material between society and nature cannot be studied exhaustively unless a simultaneous prognosis of the potential development of all resource cycles is elaborated.

Since this process takes place not only in time but also in space, resource cycles are characterized by spatial-regional structures of their own. Therefore an analysis of these structures by countries and regions is possible and indispensable. As for the Soviet Union, the economic macroregions of that country can be assigned to 5 groups, each being characterized by a specific type of regional resource cycle structure. A classification of urban agglomerations according to the local features of resource cycles seems to be equally justified.

The main advantage of this method is that it offers possibilities for ensuring the maximum convergence between studies on the general material (and energy) circulation on Earth on the one hand and the social cycle on the other. Unless this convergence is accepted, it is impossible to compile sufficiently well-founded prognoses of natural resource utilization or to preserve the necessary qualities of the geographical environment, the dwelling and working place of Man on Earth.

Most crucial in drafting the afore-mentioned prognoses is to ensure the necessary correspondence between the general circulation of materials and the social linkages. This can be done by constantly optimizing the total exchange of materials in the "nature-society-nature" cycle. As a criterion for optimizing such an exchange under socialist conditions, let us require a reduction in the input of social labour at every stage of production to the minimum. At the same time, constraints should include the rational utilization of natural materials (and energy) as well as the conservation of the natural environment.

A more detailed discussion of the concept of resource cycles and their practical application in forecasting was given by the writer in a series of special papers partly published in English in the journal "Soviet Geography" (Vol. II, No. 9, 1970).

The proposed methods of forecasting the utilization of natural resources should be combined with the application of other methods known to geographers.*

* The resource cycles method can be successfully combined with mathematical methods such as input-output analysis and linear programming, which should be used in connection with natural as well as economic systems. Interesting attempts at analysing the linkages between economic and ecological systems using this method were made by W. Isard (1968). The method proposed by E. Neef is also worth of attention.

Soviet geographers have for many years been conducting work on long-term prognoses for the utilization of natural resources. At the same time, they have developed scientific foundations for the conservation and transformation of the environment. In a separate communication on recent developments in applied geography in the USSR the character of these works is discussed in more detail.

In conclusion, let us emphasize again the great importance to geography of studies aimed at long-term prognoses of natural resources and let us invite geographers to take part as widely as possible in these investigations.

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GEOGRAPHY AND THE PROTECTION OF THE HUMAN ENVIRONMENT

by

S. LESZCZYCKI

The question of environmental politics has currently become a very live issue. All countries, and especially the highly-developed ones on whose territories various disfunctions of high intensity occur, are attempting to conduct a national policy for protecting and rehabilitating the human environment. Because many disfunctions considerably exceed the territory of individual countries, international co-operation in the field of environmental politics has been undertaken for several years. Many international organizations, connected with UNO, are also concerned with these problems. One function within this sphere is a special session of UNO devoted to environmental politics to be held in 1972. There exist, then, unusually favourable circumstances for geographers to make their own contribution to the solution of problems which are the result of the interaction between man and environment.

Geographers have long been concerned with the mutual relationships between the geographical environment and man's activity. In this respect they have accumulated vast material, have provided numerous examples of the relationship between man and the environment of the whole world, and have developed generalizations and even a theory of man-environment interaction. Recently, however, as these problems have become very topical, the former contribution of geographers has been forgotten. Now the serious task of reminding the representatives of other disciplines of the geographical contribution to the man-environment interaction problem stands before geographers. The matter of the interdependence between the geographical environment and man's activity has become complicated since solutions to these problems are only possible through the co-operation of very many different experts. Geographers must be amongst them.

Taking into account the current formulation of man-environment interaction and the environmental policy for the protection and rehabilitation of the human environment, the author would like to draw the attention of geographers to some of the problems currently standing before them.

The problems of the interaction between man and the environment has long been known. However, today they ought to be concerned with the quantitative evaluation of resources and the qualities of the human environment as a whole as well as of its particular components. At the same time, relationships, which are considered quantitatively, should deal with individual branches of man's activity as well as with the whole of his economy. These problems should now be studied with the aid of mathematical models and other quantitative methods (Fig. 1).

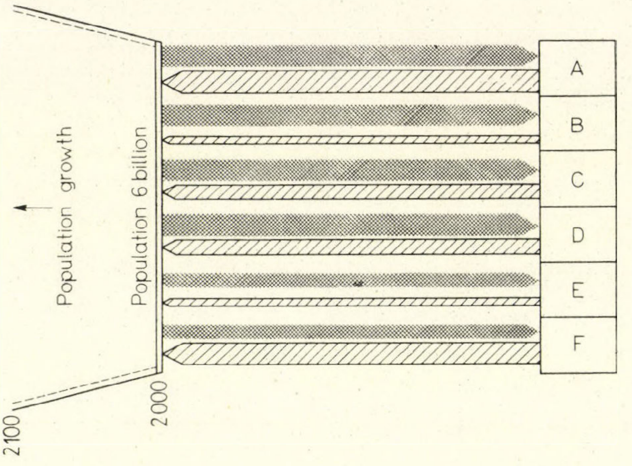


Fig. 1. Model of interaction: man and environment

A — Lithosphere; B — Pedosphere; C — Biosphere; D — Continental hydrosphere; E — Oceans and seas; F — Atmosphere

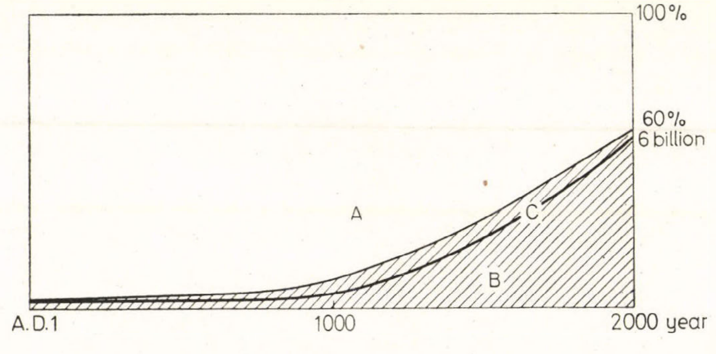


Fig. 2. Model of temporal trends in utilization of potential natural resources and population increase

A — Potential resources; B — Utilized resources; C — Population increase

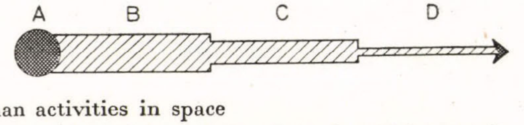


Fig. 3. Model of human activities in space

A — Settlement area; B — Intensive activity zone; C — Extensive activity zone; D — Sporadic activity zone

As is known, man's activity is growing constantly and is covering ever greater areas of the earth's surface. The intensity of this activity, however, falls gradually as one moves away from settlements (Fig. 3) and it is to be observed that the concentration of this activity occurs on relatively small areas. Together with the intensity of man's activity there occurs the concentration of disfunctions by the accumulation of various pollutions and damage in one area.

The concentration of human activity is also illustrated by the development of the settlement network, which is the result of the movement of population from small, scattered settlements to larger ones (Fig. 4).

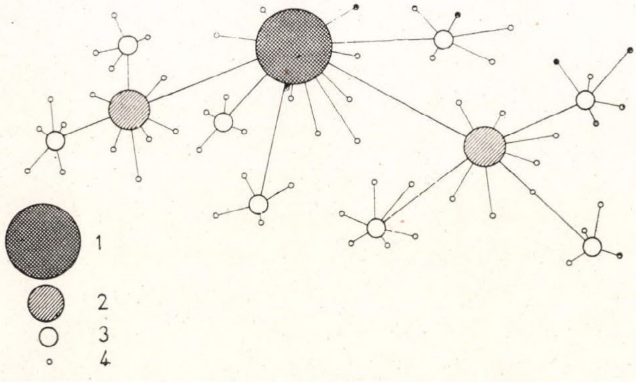


Fig. 4. Model of concentration of population in Europe in the 19th and 20th centuries
1 — Urban agglomerations; 2 — Cities; 3 — Towns; 4 — Other settlements

The exploitation of natural resources is a very important economic problem. The diagram (Fig. 2) shows a model of the utilization of potential natural resources until the year 2000 during which time the world population is expected to grow to 6 billion. The model is optimistic because it shows that by the year 2000 mankind will not yet be threatened by shortages in natural resources, which are the basis of man's productive and non-productive activities.

Man's standard of living grows with the development of the economy. However, the intensity of disfunctions increases simultaneously. In order to control them there must be a parallel increase in the contribution from state funds. This process is illustrated in a diagram (Fig. 5). It is an interesting matter to determine what percentage of the national income might be devoted to the protection and rehabilitation of the human environment. In Poland it is estimated that in 1969, 2·3 per cent of the national expenses were spent for that purpose.

It is interesting that the environmental policy varies depending on the economic level of the country in question. In general terms we can divide the countries of the world into three groups depending upon the per capita national income in dollars. In the first group are the countries where the national income is below $ 200 per inhabitant. These countries, because they are aiming at maximal and rapid economic development, usually have no environmental policy at all. In the second group are the countries with a national income of between $ 200 and $ 1,000 per person. In these countries attention is drawn to an environmental policy but the rate of economic development is always placed first and environmental policy is only considered after this and only when it does not hinder the rate of economic development. In the third group are the countries with national incomes in excess of $ 1,000 per person. These countries do have environmental policies, that is, they

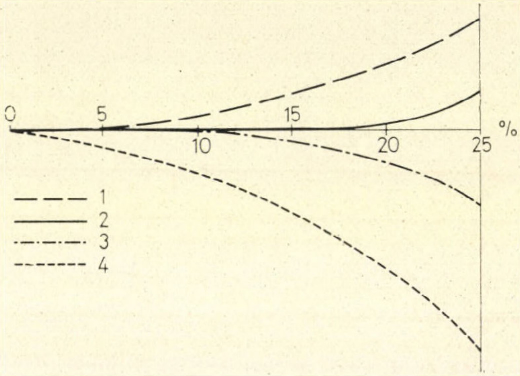


Fig. 5. Relationship between standard of living and environmental improvement costs
1 — Rise in standard of living; 2 — Increase of environmental disfunctions; 3 — Rise in environmental improvement costs; 4 — Rise in total production value

devote large sums for the protection and rehabilitation of the human environment. However, only those countries with a national income exceeding $ 2,000 per person are prepared to restrict somewhat the rate of economic development for the sake of maintaining healthy conditions for their people. As the existing high standard of living becomes compromised by bad environmental conditions, greater attention is being paid to the protection and rehabilitation of the human environment.

Geographical research in the field of environmental policy should start with the spatial registration of the state of pollution and the natural values of the environment. Therefore we can speak of the construction of maps of disfunctions and sozological maps (maps for the purpose of protection measures).

Maps of disfunctions were made for Poland in 1971 and the author would like to present six analytical and one general map. The first concerns air pollution and shows total pollution in thousands of tons of dust and gases per year. The units of reference are the larger towns or administrative units of second rank.

The second map concerns surface water pollution. On the map the pollution of rivers has been marked giving the main annual waterflow in cubic metres per second in four degrees of intensity of pollution. Also the pollution of lakes is presented in thousands of cubic metres per year, also in four degrees of intensity. The pollution of the Baltic bays and coastal waters is also shown.

The third map deals with the deformation of the relief, disturbances of groundwater conditions and also the danger from radio-active substances. Deformation of the relief on areas greater than 100 ha is marked. These are pits or open-cast mining and industrial waste tips.

The fourth map concerns the devastation of vegetation, especially of forests. The intensity of devastation is expressed in a four degree scale.

The fifth map concerns transport noise disturbance and air pollution caused by internal combustion, steam and electrical engines. The most important railway lines with traffic of over 15 thousand tons daily, or 40 passenger trains daily, as well as larger junctions and shunting depots are shown on this map. Further, there are marked the busiest motor roads, the most important concentrations of motor vehicles in towns, the busiest waterways, the main seaports and air-communication routes and passenger airports.

The sixth map shows the standard of housing in towns, distinguishing towns with substandard housing, middle standard housing and higher standard housing. When considering the standard of buildings the following household amenities were taken into account: (a) water supply, (b) toilet, (c) bathroom, (d) central heating.

A general map of the disfunctions of the human environment was constructed by superimposing the former six maps. The picture thus obtained was so interesting that it was proposed to the Economic Commission for Europe that a map of the whole of Europe should be developed in this way.

Apart from these attempts, more detailed regional maps are also made in Poland, at the Institute of Geography of the Jagiellonian University in Cracow, by a group under the leadership of K. Waksmundzki.

At the same time attempts were made at sozological maps. The maps are to cover areas which due to the qualities of their environmental conditions deserve to be protected. On these maps are to be presented national parks and nature reservations, specimens of nature, scenic landscapes, non-polluted rivers and lakes, areas where natural conditions are only slightly transformed, monuments of artistic and historical importance and others. Maps are also being made of the areas which, because of recreation and tourism should be protected from any economic activity that could cause their degradation.

These maps can serve as a starting point for geographical research which aims at evaluating the resources and qualities of the geographical environment. The valuation should be quantitative and made from the point of view of the economy as a whole and its individual branches, for instance, agriculture and mining.

Apart from maps, geographers can carry on many types of research connected either with particular types of disfunction or with the particular areas in which they occur.

The starting point for the first type of research is a classification of the different kinds of disfunction, a classification of which is as follows:

(1) air pollution; (2) surface water pollution; (3) ground water pollution; (4) pollution of seas and oceans; (5) deformation of relief; (6) degradation of soil; (7) devastation of vegetation; (8) devastation of wildlife; (9) noise disturbance and vibration; (10) bad smells; (11) danger of ionizing radiation and nuclear substances; (12) burden of household rubbish and solid industrial

waste; (13) utilization of postproduction waste materials; (14) danger involved in the low standard of dwellings, sanitary and other municipal functions.

Geographical research primarily considers spatial aspects — hence the distribution and spread of particular disfunctions. It concerns causal relationships — hence the sources of their development and the effects which they have on the geographical environment and the economy and the living conditions of man. Geographers can play a special part in research on air and water pollution and on the deformation of the relief and changes in ground water levels, etc.

The above-mentioned disfunctions arrange themselves in a characteristic way from the spatial point of view. Three zones may be distinguished:

The zone of urban-industrial agglomeration which covers small areas of concentrated production and services, where a high population density (in excess of 600 persons per sq.km) is observed (Fig. 6). This zone is dominated by a man-made environment and has the greatest pollution and deformation. The resident population frequently has substandard living conditions. The environmental policy in this zone should be concerned mainly with the rehabilitation of the environment and with the improvement of living conditions, especially with the protection of health.

The zone of intense production and other activities usually have a considerable population density (more than 100 persons per sq.km). It is in this zone that the very intensive processes transforming the geographical environment occur. Environmental disfunctions are either local or regional; occasionally they may occur in high concentration. In this zone the fundamental problems are the protection of natural resources and environmental qualities and rational methods of their exploitation. This zone may include minor centres of high population density, in which the existing problems are analogous to those occurring in the large agglomerations.

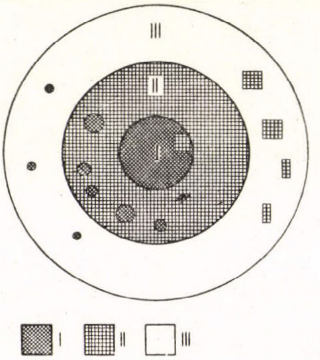


Fig. 6. The three zones of the human environment

I — Urban-industrial agglomerations and centres; Population density over 600 persons per sq.km; Man-made environment; Living-conditions; Health protection; II — Zone of intensive productive and non-productive activities; Population density over 100 persons per sq.km; Transformed geographical environment; Protection of natural resources; Optimal methods of utilization; III — Natural zone; Potential natural resources and amenities; Sporadic and extensive production activities; Protection of nature

The zone of potential resources and natural environmental endowments, where man's activities are sporadic, extensive and only locally intensive. This zone also covers the seas and oceans, as well as areas of recreation and tourism. Pollution is similarly sporadic and rather small. The primary problem in this zone is the protection of potential resources and the qualities of nature as it is to this zone that man may expand his activities in the future.

The pattern of activities responsible for the disfunctions in the three zones can be described as follows. Industrial production constitutes the most potent

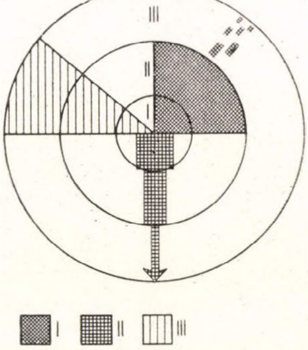


Fig. 7. Model of human activities causing disfunctions in the three environmental zones
I — Decrease in transport intensity; Zones of noise disturbance and air pollution; II — Decrease in industrial production (mining included); Pollution of air, water, soils, plants and relief degradation; Danger to health; III — Intensification of recreation and tourist activities; Environment and landscape damage

factor in polluting and deforming the environment. It is concentrated in zones I and II (see Fig. 6). In the zone of agglomeration, industrial development shows no territorial expansion as lack of space imposes, of necessity, increasingly intensive production methods. Zone I, however, is characterized by the highest degree of industrial disfunctions. Zone II, in which industrial production exhibits the broadest expansion, is also threatened by industrial disfunctions. In zone III industrial production is only sporadic and covers mainly the exploitation of raw materials, for instance, whaling.

Air pollution and noise disturbance from transport occur most frequently in zone I, to a much smaller extent in zone II, and in zone III is rather rare, except perhaps for shipping and airlines.

Agriculture is concentrated mainly in zone II, forestry in zones II and III and fishing in zones III and II. Recreational and tourist areas become important the greater the distance from zone I, but the extent of tourist facilities shows the opposite tendency. Pollution in zone III is proportional to the intensity of recreational activities (Fig. 7).

As regards disfunctions in the three environmental zones, the highest degree of concentration of pollution and deformation of the environment occurs in zone I is due mainly to the fact that the different types of disfunction accumulate in the same areas. Zone I is generally the main source of pollution. Not all types of pollution, however, have only a local extent. Some of them may spread over the whole region and thus extend to zone II. There are even pollutions of a still wider scope extending over large parts of the world, such as ionizing radiation and nuclear substances or the chemical poisoning of the oceans (Fig. 8).

The theory of the three environmental zones can be applied practically in any individual country aiming at solving the many complex environmental problems. Furthermore, this theory can serve as the foundation for environmental policy provided that adequate measures are at hand and that government intervention in the implementation of environmental programmes is secured.

In each European country specific aspects of environmental policy can be distinguished from the point of view of land use and from that of the intensity and quality of environmental disfunctions (Fig. 9). The following types of area can be distinguished:

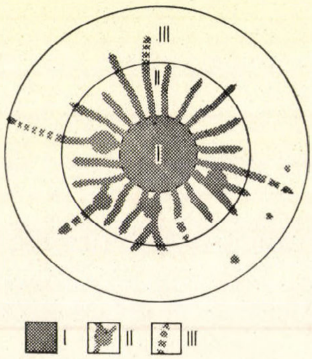


Fig. 8. Disfunction intensity in the three environmental zones

I — Zone of concentrated disfunctions; II — Zone of local disfunction sources and their expansion; III — Zone of sporadic disfunctions

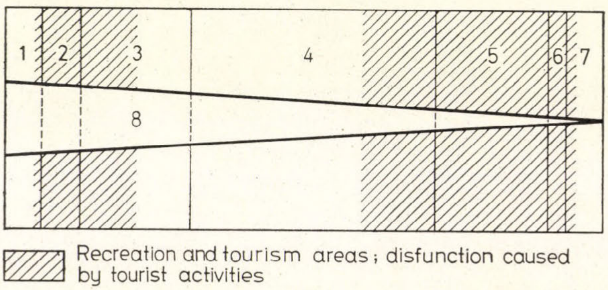


Fig. 9. Intensity and types of disfunctions within the three environmental zones (a model for one country)

1 — Centres of urban-industrial agglomerations — highest concentration of various disfunctions; 2 — Urbanized areas — various disfunctions, regional; 3 — Urbanizing areas — various disfunctions, local; 4 — Agricultural areas — pesticides, fertilizers, soil erosion; 5 — Forest areas — pesticides; 6 — Surface waters — chemical, physical and bacteriological pollution; 7 — Other and wasteland — sporadic disfunctions; 8 — Transportation areas — noise disturbance, air pollution

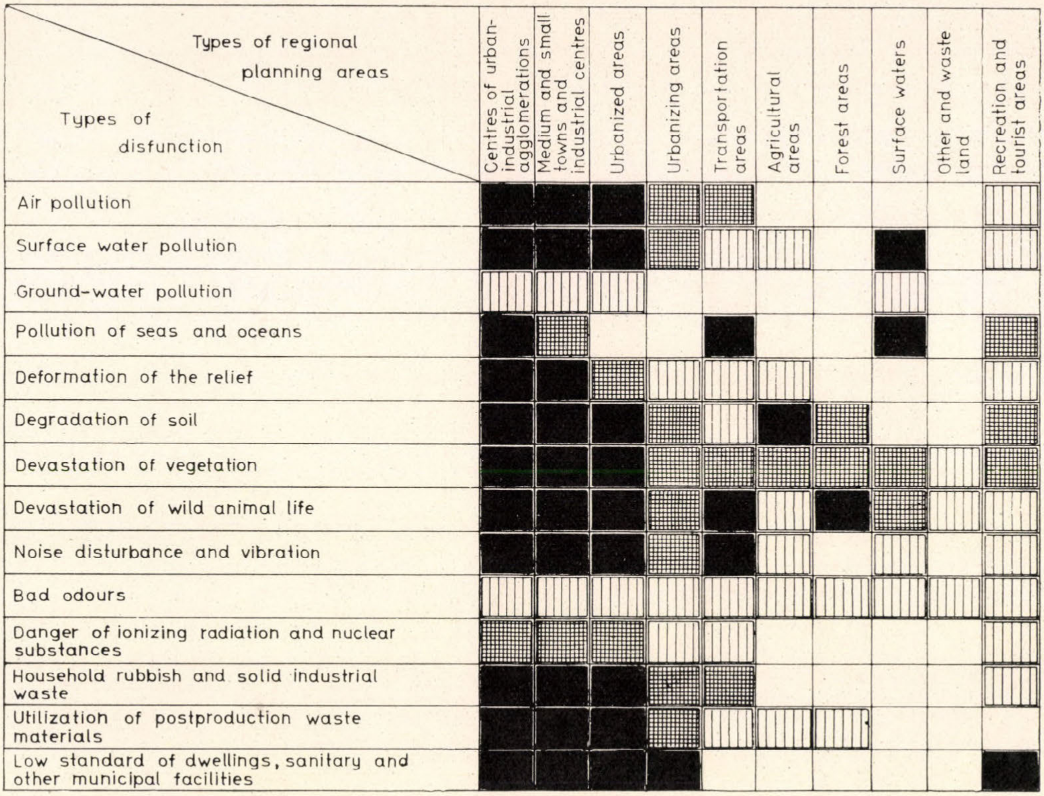


Fig. 10. Relations between types of regional planning areas and types of disfunction

(1) cores and centres of urban-industrial agglomerations; (2) medium and small towns and industrial centres; (3) urbanized areas (suburban areas); (4) urbanizing areas; (5) transportation areas; (6) agricultural areas; (7) forest areas; (8) surface waters; (9) other and wasteland; (10) recreational and tourist areas.

The classification of the types of disfunction may be joined with the classification of the planning areas on which they occur. The enclosed table (Fig. 10) forms the basis for constructing matrices of appropriate models showing the relationships between these two categories.

The above-mentioned areas may be treated as functional parts of the regional plan of one country. The areas mentioned in points (1)—(5) form a very highly invested framework, and areas (6)—(10) fill in this framework. Together, they form the spatial structure of the national economy.

Environmental policy must be based on the spatial management of the given country. The development of the spatial structure of the national economy marks out the directions of environmental policy, determines the hierarchy and the priority of the investments which aim at protecting and rehabilitating the human environment. The problems are usually concentrated in densely populated areas, in urban-industrial agglomerations which form the main centres of the national economy. In Poland we have distinguished 16 urban-industrial agglomerations which occupy 8·6 per cent of the surface of the country and include 40 per cent of the population, 67 per cent of industrial production and over 90 per cent of cultural services. These agglomerations cooperate with each other. They have an effect on nearer and more distant rural areas which become subjected to urbanizing processes. Currently, about one third of the country is undergoing urbanization. We foresee that these agglomerations will continue to develop until the year 2000. Their number will rise to 20, and the area of heavy investment will rise to 20 per cent of the surface area of the country. The presented perspective plan showing the development of the spatial structure of the national economy, marks out, at the same time, the directions of environmental policy.

That is why the contribution of geographers in the elaboration of plans for the spatial management of towns and villages, regions and the whole country, is unusually important.

COMPLEX ENVIRONMENTAL STUDIES. GEOGRAPHICAL QUESTIONS

by

M. PÉCSI

In order to meet the growing demands of commodity production and the development of science and society, the task and subject of geographical investigations has been reformulated several times. In this century, as a result of the many social and technological revolutions, this process has occurred repeatedly and in the past decades it has been dealt with more and more frequently with geographical research. In addition to highly specialized systematic research, the complex investigation of the natural environment has also developed, and to meet actual requirements, has been initiated in several scientific directions.

In Europe the natural environment has been transformed, for the most part, into "environments of human activity", or geographical environments of "humanized or secondary nature". During evolution of the means of production, mankind reacts with the geographical environment in ever more complicated ways. With the rapidly improving means of production, productive forces make increasing use of resources and other fundamentals of nature. The reasonable use and retention of the resources of the environment drawn into the process of production in such a way further the reconstruction of the locally deteriorated environment are prerequisited for the present and future existence and development of the society.*

1. REGIONAL GEOGRAPHY, "REGIONAL SCIENCE" AND LANDSCAPE RECONSTRUCTION

According to the requirements of the present day and of the immediate future, the geographical study of the interaction of nature and society is still in an initial stage. In consequence of the unforeseen pace of development in production, in the growth of settlements and in population, certain processes also accelerated abnormally in the natural environment. Natural conditions changed as a result of human activity and natural processes were locally accelerated, causing unexpected damage to human life, settlement and techno-economic establishments.

The protection and reconstruction of the landscape is closely connected with national and regional planning and, among other things with the improvement of international economic cooperation.

* In social activity these general philosophical and economic relationships cannot be sufficiently considered owing to their rapid rate of evolution and lack of adequate information.

Any landscape can be the object of regional planning and improvement. In the selection of these landscapes social, economic, political and administrative interests play a predominant role. The selection of the region as well as the direction of improvement may be considerably influenced by the preliminary results of landscape investigations. National planning and the optimalization of the economy have to take into consideration the natural resources of the environment as well as other favourable and less favourable characteristics. Further, the harmful effect of natural and anthropogenic geoprocesses on economic and technical establishments must also be taken into consideration. This is one of the conditions that emphasizes the significance of research in regional geography, landscape evaluation and landscape structure for preparing the plans of landscape reconstruction and natural planning.

The experience of national planning shows that neither the present trends of geographical science nor the results of joint environmental research satisfy the requirements of national planning.

In addition to geographical and geological investigations numerous technical, economic, administrative, etc. estimations have to be made to present scientifically based regional plans which are to be evaluated in the context of national improvement. In the last two decades in order to discover and evaluate the geographical environment a new region-researching science, "regional science" has developed. The aims of this science exceed the landscape research of physiography and rayon research of economic geography. Its domain is by no means limited, and its scope not yet fully delimited. Regional planning because of its rapid progress, needs plenty of information about the geographical environment which cannot be provided by the more traditional regional (classical landscape-analysis) sciences.

In past years, results of research in both physical and economic geography as well as in regional science show that the study of the geographical environment cannot be undertaken either solely from the physical or from the economical geographical point of view. For this reason, a complex view of the landscape and its research evaluation is necessary for increasing the economic activity of the present. The research tasks of these two geographical disciplines which are carried out by different methods are connected by the common aim of discovering the natural and economic potential of the landscape. In other words, the more effective discovery and utilization of natural resources promotes an increase in the production capacity of social work and raises of the standard of life.

We should also like to encourage geographers on this occasion to investigate landscape potentials by type. An evolving landscape typology is a significant basis for landscape evaluation. The manifold characterization of the applicability and features of the landscapes may also include the possibilities for intensified economy development. Such research accelerates the trends of the past years and favours integration within the geographical discipline and the complex evaluation of the geographical environment from the economic-technical point of view (engineering geography, technical geography etc.).

The International Geographical Union also recognized the demands of national planning as well as other regional sciences, in the domain of geography and the Union therefore decided to organize international "Regional Conferences". For regional researchers the "European Regional Conference" in Budapest was the third global discussion. The topics of the Conference as well as the various fields of interest of the participating experts indicate the interdisciplinary character of regional science.

2. "ENGINEERING GEOMORPHOLOGY" FOR THE PROTECTION OF THE ENVIRONMENT

In the interaction between nature and society the new and unique tasks of the geographical sciences differ not so much in their topics of research from the old ones but in their trends and principles. The new direction and main approaches of research in the field of geomorphology are characterized as follows.

As with several foreign geomorphological approaches, the centre of interest of Hungarian geomorphological research has focussed on the genetic explanation of single relief-types, and the history of evolution of the whole relief.

Research of mainly paleo-geomorphological orientation is characterized by structural, climatic geomorphological and morpholithological methods. In the past decades these investigations were completed by geomorphological mapping which gives detailed information on the age and dynamics of the earth's surface (Pécsi, 1964).* By means of these maps the results of geomorphological research can be utilized for practical purposes. Geomorphologists who demonstrated their relief research in complex geomorphological maps have inevitably become specialized in the evaluation of the mobility and stability of relief (the slope). Geomorphological research of this type was required for the economic and technical planning work. Employing their previous experience, a working group of geomorphologists under the direction of the author elaborated the problems of geomorphological mapping with special regard to preliminary technical planning (E. Buczkó, Gy. Háhn, S. Leél-Őssy, A. Székely, J. Szilárd; between 1966 and 1969). Although this mapping has still to be refined methodologically, the preparation of engineering geomorphological maps has now gone ahead.

On the present methods and concepts of engineering geomorphological mapping, a preliminary to engineering geological planning, more detailed information is given by S. Karácsonyi and J. Szilárd in Section VI. Information on the geomorphological and hydrographical mapping of agricultural areas delimited for soil protection, soil-amelioration and utilization, are given by L. Ádám and S. Somogyi in Section VI, and by L. Góczán in Section II.

The new methods of geomorphological research and the emphasis on technical-economic planning have been activated by practice. Experience has proved that the appraisal of the interaction, existing or potential, between the natural environment and engineering constructions is necessary for the

* M. Pécsi: Geomorphological mapping in Hungary in the service of theory and practice. Applied Geography in Hungary. *Studies in Geography in Hungary*, 5. Akadémiai Kiadó, Budapest, 1964, pp. 10—19.

TABLE I

Direct and indirect changes of relief as a result of man's technical-economic activities

Effect	Direct activities (anthropogenic impact)	Secondary processes (anthropogenic-natural) caused by anthropogenic impact
I. Excavation of the relief	1. Superficial ditching, drainage	1—2. Generation of the processes of collapse and landslide and the development of new processes
	2. Open pit, subsurface mining	2—3. The same + mechanical suffusion, collapse and break down of the surface, stimulation of surface derasion etc.
	3. Artificial planation of the relief	3. Diminution of the exogenic gravitation processes
II. Stability deformation of the relief (soil and rock)	1. Clearing of natural vegetation	
	2. Cultivation, tillage and loosening of the soil for different purposes	1—2. Soil devastation, acceleration of soil erosion, gully erosion on the slope, deflation, derasive valley-formation, transportation of materials, strenght of the frost phenomena, silting up of valley floors and channels
	3. Static load and deformation of relief by buildings	3. Superficial subsidence, compaction
	4. Dynamic load on the relief through the effect of vehicles, explosions etc.	4. Formation of loess cuts, slides and collapses
	5. Reclamation, for instance, by lowering the groundwater level	5. Soil devastation and deflation
	6. Moistening of soil, for instance uplifting of ground water, water storage etc.	6. Marsh formation, processes of slides, collapses, karst process, sodification of soil
III. Artificial silting up of the relief	1. Building of banks: roads, dams	1. Natural worsening of the run-off, bank-collapse, moistening inside the dam, drying up outside the dam
	2. Filling up: urbanogenic, agrogenic	2. Collapse, mechanical suffusion, strong filtration
	3. Spoil-banks: establishment of slag- and spoil banks	3. Compaction, collapse of spoil banks, formation of slides, clogging of superficial run-off
	4. Silting up: artificial silting up of banks and shores, ditches, depressions, etc.	4. Enlargement of utilizable areas, at the same time appearance of collapse processes

Effect	Direct activities (anthropogenic impact)	Secondary processes (anthropogenic-natural) caused by anthropogenic impact
IV. Building up of the relief	1. Relief (soil) protection, buildings: for instance engineering work stabilizing beds, banks and slopes	1. Increase in surface and slope stability, decrease and elimination of exogenic destruction
	2. Artificial covering of the surface: paving and urban building	2. Extreme acceleration of superficial run-off, strong drying of the microclima, sub-pavement freezing, subcutaneous erosion and strong mechanical suffusion, formation of collapses due to compaction and water infiltration
	3. Other artificial buildings on the relief	

choice or for the protection of sites of proposed establishments. Preliminary planning suggesting the optimal arrangement of technical-economic constructions has to include the complex evaluation of the natural environment, geographical position and geomorphological fundamentals and processes. In this way the physiography as well as the results of geomorphological research have become an integral part of preliminary planning in engineering geology.

In an earlier paper, the author had the opportunity to explain the significance of relief and to emphasize its role in present economic-technical practice (Pécsi, 1970).* On this basis and because of the demands of engineering planning he suggested "engineering geomorphology" be recognized as an individual science. The main research methods, tasks and topics of engineering geomorphology and its systematic position within engineering geology were outlined.

In the writer's opinion, the fundamental task of engineering geomorphology** is the appraisal of the stability and mobility of relief forms and subforms. Questions to be answered concern the persistence of relief forms and the respective alternation of periodic, episodic or occasional changes. The relevant regularities to elucidate are: the kind of interaction between natural factors and possible anthropogenic processes responsible for these movements and morphological changes (see Table I). A further question concerns whether the surface has actually reached dynamic equilibrium or only approximates it.

In other cases, however, when the surface is of cyclic development, it is the kind of evolution or change expected from the present stage of the relief, in the context of engineering constructions that is important.

* Pécsi, M.: Problems of engineering geomorphology. *Geomorphology. Akad. Nauk. USSR*, 1970, pp. 18—26. (In Russian.)

** Engineering geomorphology embraces practically the whole research scope of applied geomorphology, with special emphasis on the dynamics of exogenic forces and geomorphological synthesis, as well as regional geomorphology.

Engineering geomorphology, exploring mass movements and the conditions generating the frequency of morphological change, considerably increases the safety of locating and selecting sites for engineering construction.

Further it is important to estimate to what extent some of the forms and the dynamic equilibria of the processes may change with regard to the natural environment. By characterizing the different geomorphological types (e.g. slide-types, slopes liable to slip etc.) the utility of the results from the engineering view point may be promoted.

In actual planning practice there exist obligatory standards for the construction of technical-economic establishments and for the protection of existing ones. The scope of the necessary standards, for protection against the harmful effects of the environment, however, can be determined only after preliminary and thorough field investigations. Numerous precedents are known where large plants were successful from the technical design point of view, but where the complex effects of the natural and anthropogenic environments were ignored and disastrous damage was caused.

On account of such negative experiences and the requirements of safety and profitability the potential effect on the environment should be estimated before large plants are constructed.

These estimations are supported by investigations into the "engineering geomorphological" environment in numerous instances.

The most frequent investigations of this type are the following:

(1) Slopes formed during natural evolution: measuring the dynamic movement of the ground and the stability of slopes transformed by artificial excavation activities, ascertainment and prediction of the periodicity and rhythm of these movements, and determination of types.

(2) "Natural" consequences of the movements of ground and natural water: forecasts and calculation of potential dynamic changes expected upon anthropogenic intervention.

(3) Mapping of natural processes and phenomena acting harmfully on the relief and on buildings (danger of frost and drift, danger of landslide, slip and collapse, gully erosion, sites and causes of the process of silting up etc.).

(4) Objects of general theoretical and practical investigation: In the case of definite types—the trends in geomorphological change provoked by different anthropogenic activities;

— Frequent anthropogenic-natural processes, their mechanism and potential consequences and the inevitable implications of direct anthropogenic interventions;

— Methods for predicting anthropogenic-natural processes;

— Investigation of the effect of anthropogenic geo-processes is to be extended to all the natural and economic factors of the environment investigated, and all processes and phenomena caused by human activity in the geographical milieu and in the landscape are to be demonstrated on maps.

It is emphasized that the "engineering geomorphological" approach differs fundamentally from the traditional one. New methods are available, namely: quantitative geomorphology, mathematical statistical analysis in geomorphology, engineering geomorphological mapping and other computing methods.

To apply and introduce on a large scale the "engineering geomorphological" approach suggested herewith, a more detailed elaboration of the topics and of the new quantitative and experimental methods is required. This, however, can be realized only in the course of research, because further progress must be built on sound theoretical foundations. Society needs such progress and expects our scientists to realize it.

In the framework of the research problems outlined above, not all aspects of geographical environmental studies could be touched upon. It is considered necessary, however, to emphasize the need for new approaches and methods in several fundamental topics of geography.

At the same time, it seems to be practical to suggest that the Executive Committee of the I. G. U. should take into consideration and promote the development of "regional science" and outline its content by setting up a special working group or committee.

The creation of a committee on "engineering geomorphology" in order to define the detailed topics, to assess research of this kind and to submit resulting reports and material to the Program Committee of the I. G. U., will also be necessary.

SOCIOLOGICAL APPROACHES TOWARDS A METHODOLOGICAL MODEL OF ENVIRONMENT PLANNING*

by

A. SZESZTAY

Many people insist upon the fact that *environmental* protection, far from being identical with *nature* preservation, with the protection of animals and plants or with the encouragement of hiking, is an almost negligible task compared with, for instance, the replanning of our towns, the purification of water and air, and the composting of waste.

If, however, from the socio-psychological point of view the development of our relations with "nature" in the strict sense is a highly important component of environmental protection, then, and therefore from the point of view of the sociology of organizations those special activities are — regardless of their economic importance — in a key position to ensure the objective conditions of our "meetings" with "nature". Which, finally, ensure for us the place where we can interiorize the explicit values, the behaviour-patterns of the universal and of the professional conservationists' community.

> *Wilderness* is an important idea . . . part of the Geography of Hope . . . Wilderness has answers to questions that man has not learned how to ask . . . Jesus, Zoroaster, Moses and Mohamed went to the wilderness and came back with messages. It was from the wilderness, and the people who knew wilderness, that the first concern about pollution — came. Men and women who knew how water should taste, air should breathe, and grass should grow, were the first to detect when these things were happening wrong.**

Let us add: not even the routine technical tasks of environmental protection should be — that is our impression — entrusted in good conscience to such, otherwise excellent, experts who have forgotten, or have never experienced that "walking is fine . . ."***

Plainly speaking, from the indices reflecting the given level and predicting the possible development of the organized complex of a country's environmental protection — and particularly, of the social background of this complex —, the indices of *national parks* come first from the sociological point of view. And, of course, not so much their quantitative indices, as the institutional impact they have on the country's *entire* forestry and water conservation, on the *non-economic* functions (i.e. so called "welfare" — public health,

* Extracts from the author's study "East-Middle-European Models of Environment Planning". Some further extracts are to be published in *The Monographs of the Sociological Review*, No. 17. (Hungarian Sociological Studies.)

** Cited from Kenneth Brower in *The Environmental Handbook* (Ballantine Books, 1970, pp. 146—148).

*** Title of a volume by Zsigmond Móricz, the greatest Hungarian novelist in the first part of the 20th century.

education — functions) of these two big spheres of *economy*. No branch of environmental protection is without the influence of the extent to which the country's mountains, forests and waters *in general* are "*parks of the nation*", of the extent to which they serve — not to spend somehow our leisure-time — but to contribute to *the re-creation of the nations's creativity*. The "creation" and "re-creation" of personalities in harmony with nature and thus with themselves and others, are the most probable creators of material values as well.

And therefore this is what the sociologist says to the planners of recreational areas (if they are interested in his opinion):

Friends, while planning roads, hotels and public utilities for the development of tourism and drawing the boundaries of the "wilderness" so that it be an important "interlocutor" in its "climatic dialogue" with the industrial and the agricultural regions, do not forget that these "blank spots" on the settlement map are also exceptionally important cultural forums. It is there, and only there, that

— the peasants and provincial intellectuals can *continue feeling themselves at home* whose "close-to-nature" environment is more and more rapidly decreased by urbanization (they themselves desiring it most!);

— and it is here that industrial workers and the metropolitan intelligentsia can *again* "*come home*" those who suffer most from biosphere deterioration.

It is only at the scene of that meeting that recreational regions should be planned in common by experts of technical and human engineering. For it is only like this, as a quiet and breezy laboratory of interaction of not-yet and never-to-be alienated parts, that "wilderness" can become a scene, in a historical sense too, of industrial and agricultural cooperation.

However, we should not like to express the sociologist's opinion solely from the aspect — important as it be — of recreational area planning, but of the *entire* spectrum of biosphere rehabilitation.

The biosphere problem — and this is its "extensive universality" — concerns at the same time the *entire* Earth, and all humanity but in highly *different* degrees and ways according to the various geographical units. That is why it is very important that national models of environment planning have such common or at least very similar features which stimulate the closest international co-operation, but which, at the same time, reflect the geographical and social *particularities* of the given country.

However, to describe and interpret the articulation of natural and social processes in space is the most specific task of *geography*. Consequently, when formulating models of different orders of biosphere rehabilitation — and the interrelation of these models —, geographers are the primary advisers for the technical and economic planners. Beside them the sociologist has to play the part of "*ancilla geographiae*" just as he has to play that of "*ancilla ecologiae*" when summing up the diagnosis.

But we have to add immediately that the assistance of sociology is of cardinal importance — because it fills a gap — from the point of view of the history of science. If within geography, similarly to economic and political geography, there had crystallized a branch which could be called "*geography of institutional and socio-psychological tendencies*", then our geographer colleagues could do without our assistance. While they are unable to map — as they can mountains, water, energy bases, man-made constructions, administrative borders, demographic-ethnic repartition etc. — the "morphology" of human behaviour-patterns — of historical determinateness manifesting itself directly therein* — we have to represent, with our "softer" methods, this very much lacking branch of geography.

The final phase of planning is the taking into account of the potentialities helping and hindering *social mobilization* for the execution of the plans and their *feedback* into economic and technological planning itself. And this is the phase where, we consider, the sociologist should be "adviser No. 1." to the social planners of biosphere-rehabilitation (politicians) and to the managers of its technical execution. It is the phase in which the autochtonous sociological approach to the problems of environment can develop. Namely, while technological and economic planning are concerned with the objective factors — those which can be put on the map — of environment transformation, social planning is concerned with those behavioural factors in organizations and communities which cannot yet be drawn on a map and the interpretation of whose *impact on each other* is the specific subject of sociology.**

And now let us try to sum up our conception of the methodological model of biosphere rehabilitation and of sociology's place and functions in it (see the sketch model on p. 70).

The factors participating in, and affected by, the transformation of the environment, as the "independent" and "dependent variables" of the history of the man-nature relationship, can be put into the following four main groups:

(a) The most solidly "independent variables" (but which are modified by human production much more rapidly than they would be modified by their own laws) are the *natural-geographical* potentialities. The biological quality of these potentialities and the biological influence they have on man are diagnosed by ecology. This diagnosis — and the prognosis extrapolated from it —is the starting point of planning.

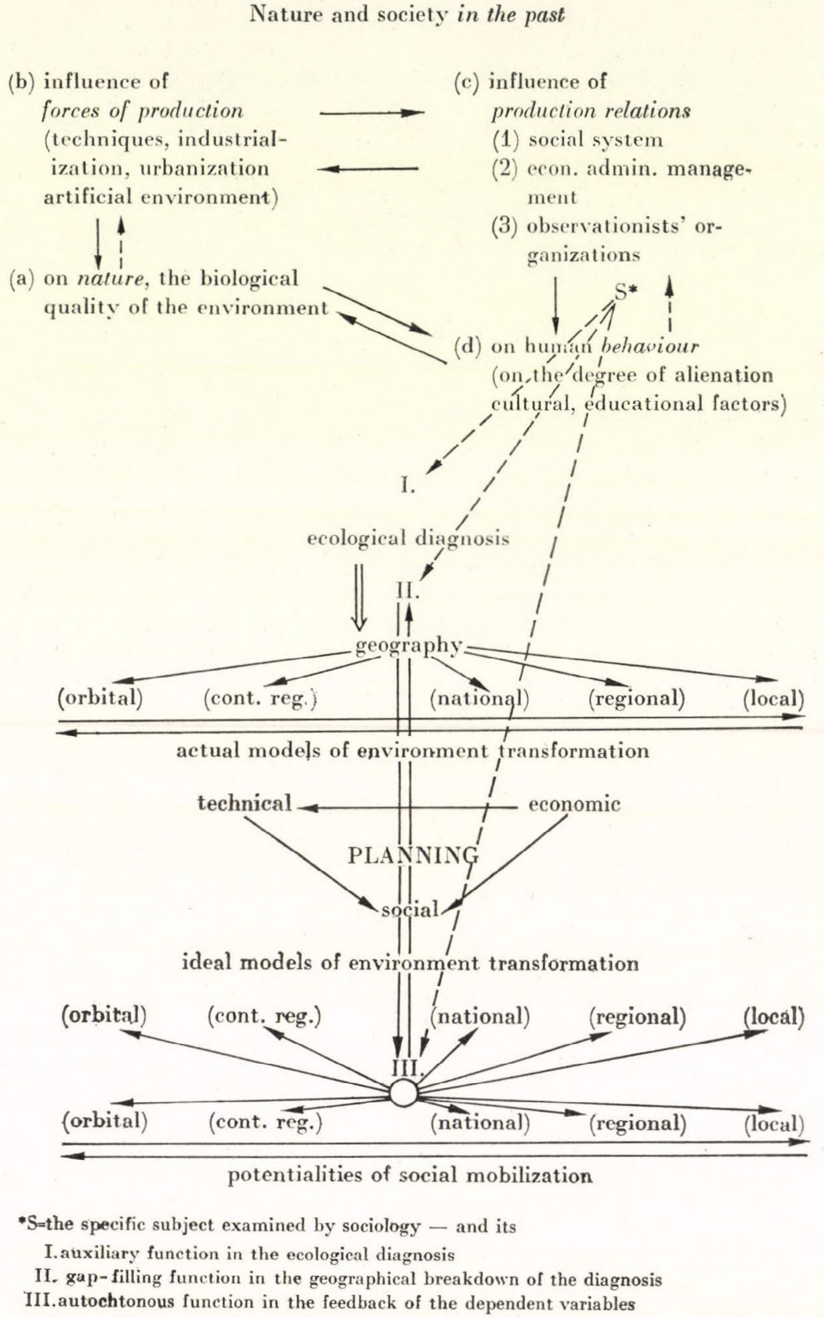
(b) From the point of view of environmental planning the *forces of production* — the degree of industrialization and urbanization, and the rhythm of economic and demographic growth, — are still definitely "independent" variables, but on a historical scale, they are much more "variable" than the natural-geographic potentialities.

The technical planning of biosphere rehabilitation presupposes the modification of this set of factors on the environment — if not by systematic concepts, by applying different technologies, and provided it can be achieved on a systematic basis, also by modifying its structure.

* Historians of ideology and philosophers of history often join the multidisciplinary discussion on the crisis of the biosphere. As far as we know, however, historians of civilization and ethnologists have not done so, or at least not to the proper degree. Yet only they could help to understand the genesis of customs, values and aspirations connected with the environment, and with "nature", which differs from land to land.

** Naturally, with the help of other sciences — thus, in order to grasp the transparency of the "natural" and the "social", primarily with that of ecology and geography — just as in the first phases of planning sociology was their assistant.

THE METHODOLOGICAL MODEL OF BIOSPHERE REHABILITATION



*S=the specific subject examined by sociology — and its

I. auxiliary function in the ecological diagnosis

II. gap-filling function in the geographical breakdown of the diagnosis

III. autochtonous function in the feedback of the dependent variables

But this — especially structural modification — can be attained only by the *mediation* of social conditions and of human behaviour-patterns and by the mediation of economic and social planning.

(c) The factors connected with *production relationships*, the social, economic and political systems are further divided into three sub-groups according to the degree of their dependence on environment planning:

(1) Though the development of socialism and capitalism (and their variants in different countries) will evidently be different from what it would be did they not meet the challenge of the biosphere crisis, from the point of view of environment planning the given *social system* of the country is doubtless an "independent" variable.

(2) Within the province of social conditions, the structure and interrelation of *organizations*, the country's *economic and administrative "management"* (based on the social system but giving it at the same time a specific feature) constitute the sub-group of the most characteristically ambivalent — partly "independent" and partly "dependent" — variables. Namely, a country can hardly radically transform its entire economic and political management merely for the sake of biosphere rehabilitation. But an efficient rehabilitation requires and involves the far-reaching reform of these managements.

(3) As for the organizations *taking a direct part* in biosphere protection, as well as their structure, their relation to organizations causing a deterioration of the environment, and the extent to which the ecological attitude has penetrated them as professional communities, these are, of course, "independent variables" inasmuch as their given state is a part of the diagnosis which is the basis of planning. As the *subjects* of economic and social planning, however, they are definitely "dependent" variables, for first of all *these* organizations have to be positioned — if necessary, by their complete transformation — to direct the technical execution of biosphere rehabilitation and the mobilization of society for the development of an "ecological civilization".

(d) Finally, the *behavioural* factors, the state of development of the conservationists' community, and the participation of this community through public opinion in biosphere rehabilitation, constitute probably the most flexible, the most "dependent" variable of the model. It would be, however, a utopian illusion to consider them, as wholly "dependent" factors which we can manipulate as we wish. For in their historical determinateness, their dependence on the not-yet- and not-to-be alienated basic communities, as well as on the cultural and pedagogical influences serving their direct modification, the patterns of attitudes towards "nature" — including all these influencing factors — are *also "independent variables"* of biosphere rehabilitation. Social planning must take them into account as some of the *objective* promoting, or impeding factors. And if social planning is democratic, it is also from the sphere of demands and aspirations that ethic-political *values* are fed into the end-model of technical planning.

We have seen that in several spheres of our methodological model — particularly in sphere (c/3), but also in (c/2) — there are some "dependent variables" which are at the same time "independent" ones as well. Social planning has to feed back the given "behaviour" not only of individuals and communities, but also that of organizations and of the whole economic and political management, as well as the historical determinateness of these "behaviours". It has to feed back the *interdependence of all these* — individual and institutional — behavioural factors. And it is here that, we are convinced, the "sociology of biosphere protection" (if it can duly prepare itself for the task) may become an indispensable adviser of social planning.

Thus from the diagnosis made by ecology, geography formulates for the planners — taking into account autochtonous economic, political and sociological (as "behaviour-geographical") features — the a c t u a l (orbital, continental, national, regional and local) models of environmental transformation.

As to sociology, by feeding back cumulatively the dependent variables as independent ones, it could formulate — in the same geographical categories — the i d e a l models of environmental transformation.

By confronting the actual and ideal models, planning could then draw up concrete alternatives of biosphere restoration from which local, regional, and national policies may be selected — taking into consideration the directly economic (i.e. pertaining to increasing production) and long-range (i.e. pertaining to the biological-aesthetic quality of the environment) interests.

But with regard to an environmental protection strategy for continental regions — and particularly a global environmental strategy — only international politics could make the choice and that, we hope, as soon as possible will be made "ecologically".

COMPARATIVE FIELD OBSERVATIONS ON NATURAL HAZARDS

by

G. F. WHITE

A persistent problem associated with human use of biological and physical environment is how best to cope with risk and uncertainty in the occurrence of natural events. Every parameter of the biosphere subject to seasonal, annual, or secular fluctuation constitutes a hazard to man to the extent that his adjustments to the frequency, magnitude, or timing of its extremes are based on imperfect knowledge. Were there perfectly accurate predictions of what would occur and when it would occur in the intricate web of atmospheric, hydrologic, and biological systems, there would be no hazard. However, there would remain the question of how, given the human aims, to respond effectively to the known, as with the rising and setting of the sun. Ordinarily, the extreme events can only be foreseen as probabilities whose time of occurrence is unknown.

The hazard attaching to the coming of the rains for dry-land farmers or the duration of peak river flow for a floodplain manufacturer or the magnitude of the infrequent but certain earthquake for a fault-zone dweller is known to be a significant element in decisions which many individual users of the environment must make on a daily, seasonal or yearly basis. The more common extreme geophysical events are avalanche, coastal erosion, drought, earthquake, flood, fog, frost, hail, hurricane, landslide, snow, tornado, volcano.

Certain of these form an important part of many government programs to buffer social dislocations from catastrophes or to improve the productivity of resource users, as witness national programs to reduce floods, prevent drought losses, insure against hail, and carry out reconstruction following earthquakes and tornadoes.

By definition, no natural hazard exists apart from human adjustment to it. It always involves human initiative. Floods would not be hazards were not man tempted to occupy flood plains: by his occupance he establishes the damage potential, and may well change the flood regimen itself. Similarly, pollution of city air comes only with human occupation, and the amount of damage as well as the physical dimensions of alterations in the atmospheric system reflect human choice among measures to alter emissions of pollutants in unsteady atmospheric conditions. Because the distinction between hazards deriving primarily from natural extremes, and those deriving primarily from human modifications of nature is blurred, it is illuminating to examine instances of air pollution hazard along with instances of flood hazard.

If the means of enabling individuals to take intelligent action or governments to design and carry out effective programs of assisting individuals are to be improved, it will be essential, along with further appraisal of both physical mechanisms and social accommodations, to have greater understanding of the processes by which people do, in fact, cope with hazards in nature. That is the aim of the collaborative program of natural hazard research supported by the National Science Foundation at Clark University, the University of Colorado, and the University of Toronto, and it has become one of the two major concerns of the Commission on Man and Environment of the International Geographical Union.

The combined activities involve collaboration among geographers and scientists in related fields along three major lines: (1) a series of comparative field observations of hazards in a variety of cultural and physical conditions; (2) eight comparative national studies, linking for each of four hazards the experience in a developing country with that in a developed country; and (3) a summary on a global scale of some of the major hazards in nature described according to a systematic outline of significant characteristics. Each national study will incorporate at least two or three comparative field observations.

The third of these efforts is intended to sharpen the thinking of administrators and technicians involved in formulating public policy with respect to hazardous events. They will be compared according to what they have in common, how they differ, and the mix of human adjustments made to them. The first and second are expected to result in a general summary of findings in selected areas and nations, and in a critical analysis and recommendations relating to geographic thought and methodology as well as to the formation of public policy. The target date for the basic papers on all three lines of investigation is July, 1972 when the IGU Commission on Man and Environment will meet in Calgary. A summary of its conclusions will be brought to the International Geographical Congress in Montreal, and later on another report will seek to draw together for wider dissemination a review of what seemed to be the more interesting and significant generalizations growing out of the investigations. A seminar to appraise research techniques and compare tentative findings will be held with the support of UNESCO in August, 1971 at Gödöllő, Hungary.

In launching observations and national studies there is no expectation that it will be comprehensive in terms of spatial coverage, types of hazards, variety of cultures, or profundity of analysis. Neither time nor money, and certainly not sophistication of method, would permit it to be so. It has seemed desirable, however, to try to carry out on a modest scale in a few selected areas a demonstration of the possible value and implications of such investigations. Those who are involved in the venture do not look upon it as a final assessment of natural hazards. Rather, they regard it as an experiment in the practicability and significance of such research. They already have evidence that it can throw sufficiently new light on environmental relationships to lead to changes in public policy in certain areas. How widely it may be useful must be demonstrated.

This paper reports on the more concrete aims, methods and possible implications of the comparative field observations.

BASIC HYPOTHESES

The observations are designed to test a series of hypotheses which have evolved over 15 years of investigation of selected hazards, chiefly flood and drought, in a few countries (Burton *et al.*, 1968). They reflect the findings and speculations of those of us who have taken part (Kates, 1970).

Perhaps the most fundamental of those hypotheses is that rational explanations can be found for the persistence of human occupance in areas of high hazard by examining the perception of the occupants of such areas and searching out their views of the alternative adjustments and the likely consequences of adopting any one of those opportunities.

In general, we suspect that there are three major types of response to natural hazards. Tentatively, we characterize these as follows: (1) Folk, or pre-industrial response, involving a wide range of adjustments requiring more modifications in behavior and harmony with nature than control of nature and being essentially flexible, easily abandoned, and low in capital requirements. (2) Modern technological, or industrial response involving a much more limited range of technological actions which tend to be inflexible, difficult to change, high in capital requirement, and to require interdependent social organization. (3) Comprehensive, or post-industrial, response combining features of both of the other types, and involving a larger range of adjustments, greater flexibility, and greater variety of capital and organizational requirements. We hypothesize that the United States currently is passing the peak of the modern technological type and is beginning to catch glimpses of the comprehensive type as it emerges here and elsewhere.

It is also hypothesized that variations from place to place in hazard perception and estimation can be accounted for in considerable measure by a combination of factors embracing (1) certain physical characteristics of the hazard, (2) the recency and severity of personal experience with the hazard, (3) the situational characteristics of decisions regarding adjustments to the hazard, and (4) personality traits.

We have been inclined to try to describe choice of adjustment in terms of a perception model dealing with the individual manager's subjective recognition of the hazard, of the range of choice open to him, the availability of technology, the relative economic efficiency of the alternatives, and the likely linkages of his action with other people.

We further hypothesize that there are significant differences in the way in which these factors interact in relation to community action in contrast to individual action.

FIELD OBSERVATIONS

The time now seems ripe to try to test these more rigorously. The comparative observations are being selected with a view to examining a variety of hazards in a variety of cultures. Ideally, we would have liked to find a number of areas in which the geophysical conditions were similar and the culture radically different. This was not always practical. The limiting condition often was the availability of competent geographers willing to join in the work. As of early 1971, observations were completed or planned in the following areas:

Hazard	*Area*
Coastal erosion	Scotland
	United States
	Wales
Drought	Australia
	Brazil
	Mexico
	Tanzania
	United States
Earthquake	Peru
	Sicily
	United States
Flood	Canada
	Ceylon
	France
	India
	Japan
	United Kingdom
	United States
Frost	United States
Hurricane	Pakistan
	United States
Landslides	Japan
	United States
Snow	United States

In addition, it will be possible to draw upon much work of similar character already complete, that did not follow the same pattern, but touches on the basic hypotheses.

BASIC STUDY METHODS

The methods employed for analysis grew out of studies supported by the National Science Foundation and, earlier, by Resources for the Future and the Rockefeller Foundation. They are based upon: (1) a careful description of the characteristics of sites studied, and (2) a searching interview.

Site description includes the more conventional attributes of land form, soil and vegetation types, land use, and population. It reviews the sequent occupance of the area and estimates the mean and range of annual income. Attention is given to distribution in time and space of the hazard as well as to damages resulting from it over the period of historic record. An effort is made to judge the importance of the particular hazard to the economy and social organization of the region and of the nation. There also is assessment of the flexibility of the adjustments and of the circumstances in which people appear to choose the way in which they cope with hazards.

The interview elicits information about the social and economic status of the household, the conditions in which it is obliged to make decisions in the face of the specified hazards, and the precise types of adjustment which are made or which are perceived as being made by others. The factors entering into the choice of particular adjustments are probed. The interview contains several measures of personality traits, including a story in which the respondent selects what he regards as the most suitable outcome, and a sentence completion test which is coded for characteristics of external-internal control, traditionalism-modernism, and feelings toward hazards.

This basic interview is modified from place to place in order to take account of differences in local environment. However, every effort is made to ask the same key questions in every observation site.

The interview typically takes about an hour. Approximately 120 respondents are sought in order to permit a size of sample population large enough to carry out elementary tests of association among two or more of the characteristics recorded.

Ideally, the interview and site description would give accurate and full information about each segment of the decision-making process, including the perception of environment and of possible adjustments to it. In such a venture, the factors of personality would be sorted out from those that relate to the decision-making situation or to the role in which the respondent sees himself in making his choice as it affects not only his own welfare and that of the community. Individual respondents would be sorted out according to personality traits, their particular decision situation, and the anticipated effects of whatever choices are open to them.

In practice, it is impossible to test all of these characteristics in the model. Because of difficulties of inquiry or of analysis, a more limited number of them is dealt with. The present design relies on very rough measures of personality traits, defines the decision situation only in approximate terms, and fails to work out a precise estimate in monetary terms of the expected costs and benefits of the choice of particular adjustment. In this regard, the observations lie somewhere between the highly controlled laboratory situation in which most psychological testing of risk-taking has taken place and the rougher field studies made by social scientists of how people behave in the face of uncertainty in dealing with environmental parameters.

With this evidence it is possible to partially explore the hypothesized relationships. Certain of them, such as the effect of personality traits upon choice, would be expected to lend themselves to testing within individual sites where culture is uniform and natural parameters are similar. Others, such as the relationship between type of social organization and the number and character of practiced adjustments, will be examined best in comparisons among sites having different cultural configurations. The full analysis has just begun.

LIKELY OUTCOMES

From the comparative field observations it is hoped will come a number of new insights into the ways in which man deals with hazards in the environment as well as specific suggestions for improving public policy in guiding such adjustments.

In the long run, the more important contribution of the observations may be to spread among scientific and administrative groups a mode of approach which asks systematically what is the nature of the hazard, what are the adjustments which individuals conceivably could make to them, and what accounts for the particular choices which individuals make at specified places and times. This point of view, relatively familiar to many geographers but rarely applied in engineering or in natural scientific approaches to hazard situations, may be expected to have a major influence upon future thinking about both individual and community responses to uncertainty and risk in nature.

Experience with flood policy in the United States and Canada (U. S., 1966; Sewell, 1969) and with application of these approaches to extreme situations in East Pakistan and Peru give some reason to think that as additional findings become available they will be translated into national action.

At the international level, it is hoped that the investigations will stimulate agencies, such as UNESCO and FAO, involved in giving technical advice to national groups on resources matters to take a somewhat different stand in providing services, educational information, and training. We have an example of this in the United Nations seminar on flood loss reduction held in the Soviet Union in 1969 (White, 1970).

How much we shall have to say at the time of the United Nations Conference on the Human Environment in June, 1972 remains to be seen. One of the major themes emerging for that conference is the rising menace to the welfare and survival of the human race posed by environmental modifications, notably contamination of air, water, and soil. How man perceives those threats and the kinds of adjustments he makes to them are crucial. If there is anything we have learned from studies of natural hazards it is that public awareness and publication of scientific reports need not lead to constructive response. While being wary of false analogies, we should ask what human recognition and steps to deal with deterioration of the global environment have in common with adjustments to the more conventional geophysical hazards.

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TOWARDS A GLOBAL SUMMARY OF NATURAL HAZARDS

by

A. U. WHITE

The hazards which man confronts in natural systems and his range of ingenuity in dealing with them are so diverse that it may be asked whether anything is to be gained from summarizing them on a global basis. Experience so far in the collaborative research on natural hazards which has been supported by the National Science Foundation and UNESCO suggests that important benefits may come from examining the whole spectrum of hazards and from presenting the summary results in a form intelligible to scientists and policy makers in other fields.

The effort at description desribed in this paper is aimed at two groups of users. First are the scientists and engineers who are highly competent and knowledgeable in studies of one hazard such as floods or drought, but who have had no occasion to appraise their activity by comparison with similar activity relating to other hazards. Second are the public policy makers and administrators who may be expected to apply scientific findings, but who have difficulty in understanding the differences among hazards and in determining what public responses are most appropriate for their particular culture and environment.

All too often the scientist or engineer investigates one aspect of one hazard in one place without being aware of other relevant aspects and experience, as when hurricane flooding is studied solely from the standpoint of building levee protection. It is rare, indeed, that public officials in their turn approach a problem of natural hazard with consideration of all possible types of adjustments. Both groups tend to perceive their problems in specialized and limited terms. Our effort is to compensate for such specialized views in part by providing in a form intelligible for non-specialists a view which is essentially a geographic view. It looks at a range of hazards in all parts of the world and attempts to suggest pertinent questions and generalizations. It asks the engineer specializing in hurricane flooding to consider what can be learned from the same hazard in other areas or from other hazards in the same area.

AIMS OF A GLOBAL SUMMARY

The object of a global summary of environmental hazards is to examine a number of extreme geophysical events and a few hazards of a biological nature with a view towards describing them in a uniform fashion so that there could be a scientific basis for comparison.

Vast exchanges of energy take place in nature every day, and while man has learned to make use of many of these, in other cases he must protect himself from harmful effects. At times these forces are such that man is overwhelmed by them and this we call a natural disaster. Without the energy of the sun man could not live on this planet, but specific forces such as floods or winds may require considerable ingenuity on his part if he is to survive in conjunction with them. It is the interaction of man and nature that gives rise to natural hazards; as man builds more complicated societies with a complex technology he may subject himself to an increasing potential of damage from these forces. Without houses and crops in a flood plain there would be little damage from a flood, and man was not harmed by clear air turbulence until he built jet planes to fly in the upper atmosphere. One aim of a global summary is to show the distribution of these hazards over the globe, and to indicate that some portions of it may be subject to several or more hazards in varying degrees.

A second aim is to facilitate the comparison of the kinds of adjustments which people have made in different places in coping with these hazards. These may range from doing nothing at all to individual and community attempts to prevent or modify the damage. Warning systems, for example, may be very useful in flood situations where there is a good communication network, and almost useless where there is no radio network. As yet there is no forecasting capability for earthquakes. Men differ also in the extent to which they perceive the hazard and possible adjustments to it, and these perceptions can be compared for different hazards and different cultures.

Types of environmental hazards

The types of environmental hazards to be considered are listed below.

Extreme geophysical events:

Climatic and Meteorological

- Cold waves
- Clear air turbulence
- Drought
- Floods
- Fog
- Frost
- Hailstorms
- Heat waves
- Hurricanes and typhoons
- Lightening strokes and fires
- Snow and blizzards
- Seiches and surges
- Tornadoes
- Wind storms

Geological and Geomorphic

Avalanches
Earthquakes
Icebergs
Landslides
Shifting sand
Tsunamis
Volcanic eruption
Coastal erosion

Biological

Disease
Pests
Weeds

ELEMENTS OF A SAMPLE DESCRIPTION

The characteristics enumerated below can be used for any hazard, but they fit each one in varying degrees. It may be useful to see how they apply to two rather dissimilar natural hazards, floods and clear air turbulence.

Definition: This presents no particular problems. A flood may be briefly described as a stream flow which exceeds the bankfull capacity of the stream. Clear air turbulence usually refers to a variety of irregular fluctuating motions occurring several kilometers above the earth's surface in air free of clouds and strong convection currents.

Spatial distribution: This is quite dissimilar. While floods take place chiefly where there are streams, clear air turbulence can take place almost anywhere in the earth's atmosphere, reaching its peak at an altitude of 9—12 kilometers, the zone most commonly used by jet planes.

Magnitude: With a long history of observation on some streams, terms of magnitude of floods has been pretty well codified, expressed either by volume, such as cubic meters per second; or as flow in terms of its estimated recurrence interval, as a recurrence interval of 1 in 500 years. Clear air turbulence, a relative newcomer as a hazard to man, has no such clearly defined and universally used measurements, although there are some criteria that are being developed using speed, gusting, and the effects of turbulence on aircraft and passengers.

Frequency and forecasting capability: At present information levels it is not possible to estimate frequency of occurrence of clear air turbulence nor to forecast it accurately although in the middle altitude of the northern hemisphere there is a stronger probability of occurrence in January and February. Similarly, floods are seasonal in many hydrological areas, but the occurrence of a particular flood cannot usually be predicted until the hydrological conditions for it have begun to develop. At that time prediction is possible, especially for broad-crested floods.

Warning time: The warning time for broad-crested floods may be as much as 30—50 days. For sharp-crested floods due to cloudbursts in arid regions, the warning time rarely can exceed a few minutes to one hour or two. Clear air turbulence is similar to the second type in that the warning time is at best brief, but unlike floods its exact location cannot be pinpointed by present forecasting methods, and it may be encountered by aircraft with no warning whatsoever.

Duration and areal extent: Overbank flow in floods may last from a few minutes to several months, covering a few acres to many square miles of land. A patch of clear air turbulence is usually quite narrow and can be crossed by a jet plane in less than 4 seconds, resulting in a severe but solitary bump.

Damage potential: The damage potential of a flood is a function of the waterflow characteristics and the land use in the area subject to flood. With bumps due to clear air turbulence the main results are injuries to people and stress or outright damage to the plane. Estimated costs of clear air turbulence to commercial aviation in the United States were $ 12 million* in 1964, whereas the 1963 damages from floods were estimated at $ 186 million.** These costs for clear air turbulence include as a major component the cost of directing aircraft around areas of suspected turbulence, but for floods protective works and avoidance procedures are not included in damage estimates at all.

Adjustments: The principal adjustments to floods cover pretty well the range for any hazard: bearing the loss; sharing it through public relief and rehabilitation or subsidized insurance; control measures; emergency warnings and evacuation; structural changes; and changes in land use. For clear air turbulence four of these have been used so far, bearing the loss; structural changes to aircraft; emergency measures of avoidances and techniques of minimizing injuries; and insurance for injuries. The U. S. airlines have had little help from the government in dealing with damages, such as is the case with floods, although there is generally considerable help from national governments in forecasting and warning systems.

Perception of hazard and adjustment: It is rare that the perception of the hydrologist with respect to floods coincides with that of the flood plain residents, and it is not known whether the usual air passenger sees clear air turbulence as a specific hazard apart from the general risk of flying. The individual resident or a public agency dealing with floods generally does not have an active awareness of the full range of possible adjustments, and actually uses only a small number.*** The airline passenger has only the options of not

* U. S., National Committee for Clear Air Turbulence, "*Report to the Federal Coordinator, U. S. Department of Commerce*". Washington D. C., U. S. Government Printing Office, 1966, p. 11.

** Task Force in Federal Flood Control Policy, "A Unified National Program for Managing Flood Losses", 89th U. S. Congress, Second Session, *House Document* No. 465, 1966, p. 4.

*** Robert William Kates, *Hazard and Choice Perception in Flood Plain Management*, Chicago: University of Chicago, Department of Geography Research Paper No. 78, 1962.

flying at all, or of minimizing the risk by keeping his seatbelt fastened, and may not be aware of the reason he is requested by the airline to do this. The airlines, with access to more meteorological information, have a greater perception of the hazard, but their adjustments are limited by the state of precise knowledge of the causes of clear air turbulence.

PROBLEMS OF DESCRIPTION

This brief summary illustrates the difficulty of comparing rather disparate hazards where the information is not always global or comprehensive in character. For many extreme events there is specific information from some parts of the world, with careful estimates of damages, in others there is considerably less precision.

For some hazards, terms like "damages" have come to have customary meanings that need to be made explicit. For example, as shown in the discussion of damage potential for floods and clear air turbulence, the latter includes avoidance procedures as a major part of the estimate of damages; for floods prevention measures are not usually included at all in damage estimates. This illustrates the need for a careful and comprehensive method of examining all costs to the indvidual and to society connected with each hazard and the adjustment man can make to it.

In addition, there is need for the development of useful comparative indices such as a measure of fatalities, reflecting the degree to which dangers from a hazard are accompanied by loss of life, or a measure of adjustment which would attempt to describe the particular mix of adjustments used to deal with each hazard, probably on a regional basis.

Another problem is that of steering a course between useless generalization and technical jargon incomprehensible to the non-expert. Mark Twain once described how to harness a horse without using any technical names for any parts of the harness. The resulting welter of buckles and straps was very amusing, but did not help to hitch up the horse.

Despite these problems, it is hoped that a comparison of the characteristics of hazards in regard to knowledge of their physical nature, the perception man has of them, and the adjustments he can or does make to them, will stimulate thinking by both policy makers and scientists as to more effective policy in dealing with extremes in nature. Geographers are invited to suggest ways of sharpening the analysis and improving the available data.

II. REGIONAL CASE STUDIES OF ENVIRONMENTAL PROBLEMS

THE PRESENT STATE OF THE NATURAL ENVIRONMENT (BIOSPHERE) IN EUROPE

by

I. P. GERASIMOV

The present state of the natural environment in a number of European countries as well as the measures which are undertaken for its protection and improvement are characterized in the regional surveys set forth below. The countries are different in their geographical situation, population number and area, they differ in levels of technological and economic development and in social system. Both the present state of the natural environment and the various measures directed at its preservation in these countries are diverse. However, from the above surveys it becomes clear that alongside with rather essential differences peculiar to every country there exist several common features.

The most important among these common features are general anthropogenic changes in the natural environment which have occurred as the result of economic and other types of human activity. None of the European countries considered below is at present in the possession of considerable virgin areas except for relatively small special reservations. Even on the largest national territory of Europe — namely, the European part of the USSR, — in its least spoilt regions (for example, in the North-East) nature has been considerably transformed by man. The taiga forests are greatly affected by clearing; the natural regimes of rivers have suffered significant transformations due to various hydrotechnical installations; considerable tracts of land are being ploughed for agricultural purposes; and great changes have occurred in the composition of wild fauna as a result of protracted hunting, game-shooting and trapping.

It is important to note that on account of the degree of total anthropogenic change in the natural environment, European countries of various sizes with varying densities of population and levels of techno-economic development, are quite comparable with one another. Thus, for example, Spain and Italy can be compared with Great Britain and The Netherlands. At first sight, the natural environment of the latter two — more highly industrialized countries — appears to be less destroyed by man than that of the first two countries. Such an impression however is, of course, completely erroneous. It is general knowledge that the existing natural environment of Great Britain, The Netherlands, the Federal Republic of Germany, as well as of the German Democratic Republic and Czechoslovakia is primarily anthropogenic, i.e. highly transformed or even created a new by man. Their natural environments seem to us to be less destroyed than these of some other countries only because of certain historic and geographical reasons (see below).

Such a deep and radical change in the natural environment of European countries is caused, first of all, by the long exploitation of natural resources and chiefly by the spontaneous, i.e. non-regulated character of this exploitation. The intensity of exploitation by man in Europe was, of course, irregular both in time and in space. It started many thousands of years ago, and judged by a number of indices gradually approached its present critical level.

Thus, during the Roman Period, when slavery was common, this exploitation of nature occurred in the "barbarian" domains in order to supply Ancient Rome with various natural products. During the feudal Middle Ages it increased considerably in many European countries that gradually strengthened their economic position by enlarging their arable land, and pasture. The development of manufacturing industries widened still more the anthropogenic pressure on the natural environment of Europe, first of all, by exhausting wood resources for building purposes (ship-building, in particular) and by charcoal making.

The most radical turning-point in Europe, however, was associated with the industrial revolution, the introduction and development of capitalism, and with the final change-over from domestic handicraft to large-scale machine production. This took place in the 18th–19th centuries. Therefore the last one or two hundred years man's influence on nature, because of its intensity and diversity, has surpassed that exerted during thousands of years of preceding history. Aside from the intense use of mineral resources (iron and other ores, coal and later oil and gas) as well as a further increase in wood cutting, this period was marked by an almost continuous ploughing up of all land fit for agriculture and by a rapid growth in the number of towns and great industrial centres which deeply transformed the whole natural environment.

The imperialistic phase of development of capitalism, the progress in contemporary science and technology, the emergence of a camp of socialist countries in the world arena appear to be the most important events in the latest period of European history. Taken separately and together, these events played a decisive role in establishing the present interaction between mankind and the natural environment. These interactions have now attained a high level of intensity; they have reached — in many respects and in the majority of European countries a crisis point. This situation calls for an urgent and constructive solution.

Such is the historical development of the interaction between society and the natural environment in Europe and in other parts of the world. It is, on the whole, a universal characteristic and accounts for the common features of the present state of the natural environment in various European countries.

The fifteen regional surveys on the present state of natural environment in European countries are divided into three main groups: the capitalist countries of Western, Southern and Northern Europe, the socialist countries of Central and Eastern Europe and the Soviet Union. Such a division originating from the social structure of the countries and from their geographical situation has a definite purpose. It must facilitate the understanding of the role played by the social factor in the present interaction of man with his natural environment. It must be utterly clear that it is the social factor that in the long run determines the essence of such interactions. Any personal attitude of man towards nature is submitted and interpreted through his social class interests and through the social structure of society. It is reflected in the latter and is realized — in its most efficient manifestation — in collective measures of some form or other. As will be said below such an approach to considering the material set forth above gives us the possibility of drawing general conclusions.

Among the basic tendencies of decisive techno-economic progress the following can be singled out:

Expansion in volume, increasing intensity and radical changes in the structure of present industrial production;

New trends and progress in agriculture, forestry and in other branches of the economy, as well as in transport, which strengthen general industrialization;

Steady outflow of population from rural to urban places;

Rapid development of urbanization;

Increasing role of recreation.

The continuous and rapid expansion in volume and the growing intensity and radical transformation of industrial production, first of all, strengthen the following major influences on the natural environment:

(a) increase in volume of consumption, as well as an enlargement in the structure of natural resources used;

(b) increase in volume and enlargement of the structure of industrial waste;

(c) increase in waste anthropogenic energy (mostly of heat) dissipated into the surrounding environment.

It is not possible to consider here in detail the above-mentioned phenomena and processes. This has been done to a considerable degree in regional surveys. In order to explain what has been said above, however, it is worthwhile to point out some of the consequences associated with the above-mentioned processes. Thus the rapid growth in the number and size of ore-mining sites in many European countries is direct evidence of the continuous increase in the volume of mineral resources involved in present industrial production. Increases in the volume and structure of industrial waste, on the other hand, is one of the main reasons for growing air pollution and water contamination, particularly in large industrial centres and also in the accumulation of industrial refuse of various kinds, from mineral waste to waste dumps in towns. And lastly, the growth in industrial heat waste, first of all, due to power station cooling devices and also to the dissipation of warm industrial sewerage undoubtedly change the natural heat balance and violate the corresponding natural equilibrium.

The present trends and forms of progress in agriculture and forestry, which increase their degree of industrialization, also introduce rather diverse and important changes to the natural environment. The following ones can be singled out as the most universal:

(a) Gradual reduction in the total area of arable land, made possible by modern chemical fertilizers, mechanization and land improvement and the convertion of poor and other lands to forestry, fodder production and recreation purposes.

(b) Expansion in the volume and the raising of animal breeding standards made possible by cultivated hay-mowing, pasture land and proper pasture cycles.

(c) Improving the level of forestry by increasing the productivity of plantations (selection of species, fertilizers, measures taken against pests etc.) by rational methods of forest exploitation and use of wood and by efficient forest-planting.

Alongside the general reduction in arable land allotted to crops for human consumption and fodder crops, an optimum degree of afforestation is necessary.

(d) Increasing application of various chemical fertilizers and of other chemicals (pesticides, biostimulators etc.) in agriculture and forestry. Alongside the positive effects (raising of crop yields) it intensifies the processes of eutrophication in waterbasins which damage water supplies and fisheries.

The latest technological progress in transport and, in particular, the exceedingly rapid growth in automobiles, as well as air transport have important and well-known consequences. First and foremost, it leads to the irrepressible growth of air pollution and noise levels. The consequences of the development of supersonic aviation in the higher layers of the atmosphere are as yet less clear, but the consequences will probably be negative for the natural environment.

The steady flow of rural population to the towns and the rapid development of urbanization have diverse consequences for the natural environment. Alongside increased urban comfort, urbanization can also exert a negative influence upon human activity (for example, poisoning of the air and water, noise and unfavourable microclimatic changes etc.).

The increased role of recreation is in close association with the development of urbanization. It is recreation that is at present the main "remedy" for the negative consequences of urbanization: hence the heightened interest in all recreational measures.

Information set forth in regional surveys on the present state of the natural environment in the eight capitalist countries of Europe makes it possible to establish some common features. In spite of their universality their manifestation are rather diverse. This can be explained first of all by the fact that every one of the countries in question entered the present period of scientific and technological progress under different conditions. The countries differ in natural resources, have gone through different paths of technological, economic and cultural development and due to this very factor they have rather different "inheritances". The countries also vary substantially from one another in their areas, in the number of their population and in a number of other features.

However, the common features and the measures undertaken with a view to conserving and improving the natural environment, i.e. the features that bring the countries in question closer to one another, should be highlighted and their importance pointed out. They are as follows:

The general public of every country is becoming increasingly aware of the deterioration of their natural environment and of the need to improve it and to conserve natural resources. The worst offenders are air pollution, urban noise, lack of fresh water and decline in fisheries;

Protection of natural environment enforced by the state (limitation of industrial waste discharge into water-basins, and of smoke and exhaust gases into the air; regulation of hunting and game-shooting and others);

Increased recreational facilities (national parks etc.) and the protection of certain species of vegetation and animal life;

Education of the public by means of propaganda of the necessity to protect the natural environment;

Support for and active participation in international measures to protect and improve the environment.

To render these general propositions in a concrete way, let us consider the actual situations in some capitalist countries. It is expedient to divide them into several groups.

Great Britain, the Federal Republic of Germany and The Netherlands can be referred to the first such group. As is known, all these countries are limited in area, are densely populated, and highly industrialized, which has for long been of major importance to their economies. Therefore the negative consequences of technological progress upon the natural environment of all three countries are very strong; the contamination and poisoning of air and water is widespread, accumulations of industrial and domestic waste are huge, and large areas of land are occupied by urban, industrial and road construction to name but three consequences. Since all three countries are densely populated and highly developed, measures to weaken the above-mentioned harmful phenomena are energetically undertaken as a "self-defence". Thus, for example, in London they have almost completely eliminated smog, while in the FRG and Holland projects for making recreational zones out of reclaimed sand-pits (for instance, the dolomite landscape in Haggen) and the creation of suburban green belts (for example the Amsterdam Wood) have been realized. Some protection measures in respect to flora and fauna are being undertaken mainly on the initiative of the public. In Great Britain, due to the humid climate, the subordinate role of agriculture in the economy of the country and to the still surviving traditions of the privileged classes who hunt and partake of other sports in the open air, the countryside in many places is still unspoilt.

None of the countries in question has overcome the most important negative consequences of industrialization and urbanization. The mining and industrial regions of these countries are characterized by high levels of air, water and soil contamination. Holland is subjected to great pressure from neighbouring Belgium, the FRG and others, especially along the Rhine, which at present is the "sewage canal" of Western Europe. It is remarkable that here a high level of surface water contamination hinders secondary eutrophication. Briefly speaking, all three countries under consideration are in a rather difficult situation so far as the natural environment is concerned and the public of these countries is justly anxious about the future.

The second group of capitalist countries is composed of France, Sweden and Finland. The present state of the natural environment in these countries differs substantially from that described above, due to their somewhat different course of economic development. Simultaneous industrial development, advances of agriculture and forestry over considerable areas and a relatively low population density, were characteristic of all the three countries. This allowed the preservation of secondary forest and also weakened the "pressure" of modern industrialization upon the natural environment owing to an even distribution of industrial centres. The traditions of limiting amateur hunting (as in France) and regarding forests as important sources of raw materials (as in Sweden and Finland) also played a positive role in weakening this "pressure".

Industrialization, however, in all the three countries in question grows rapidly. Their population concentrates more and more in towns and cities. Air pollution and water contamination increase, and the eutrophication of water-basins develops speedily which kills off the fish. Numerous mountain regions become deserted, which are set aside for tourist and recreational sporting zones.

Water contamination has become especially acute in Sweden and Finland where it has spread even to the coastal zone. Under public pressure still stricter laws on nature protection are being introduced in all three countries. These laws, however, do not eliminate all dangerous phenomena since they conflict with the interests of free enterprise. Thus, though the situation of the countries in the 2nd group is not as bad as those in the first, on the whole there is a deal of public concern for the future.

Italy and Spain form the third group. Both countries are situated in drier areas, are densely populated and have had long and complicated economic histories. Although up to the present, these countries have mostly been agrarian, some elements of their environments have been destroyed owing to deforesting, unsystematic ploughing and use of pastures, an unfavourably changed water discharge, erosion and other phenomena. Thus, in this respect both countries have suffered from the severe heritage of the past.

At present Italy and Spain are becoming rapidly although unevenly industrialized. Apart from the negative consequences of urbanization (air and water pollution in rapidly growing and badly planned city centers are created) people are also rapidly leaving agricultural areas for the towns and deserting the mountain regions. In Italy in order to conserve these regions plans are in hand for creating recreational parks and reservations for tourists. In Spain energetic measures are being taken to carry out hydrotechnical construction work for developing power stations, to ensure water-supply and to provide irrigation. However, the situation is not greatly improving. Thus, at present both countries experience the heritage of their past as well as the negative effects of modern industrialization and urbanization. The public in both countries understands the problems and expresses great concern.

Let us now compare environmental conditions in capitalist countries with those in socialist ; the latter will also be considered in groups.

The German Democratic Republic and Czechoslovakia are included in the first group. Of all the socialist countries of Central Europe these two are the most industrialized. It was only 25 years ago that they chose the socialist way of development having already had an essentially industrial past. However, this potential included an environment badly damaged under capitalism. Therefore, both countries industrializing further by means of expansion and modernization had to take measures to lessen and overcome the negative phenomena not only inherited from the past but also arising because of the latest technological progress. There is no doubt that great difficulties have thus been created.

They appear in the increasing air and water pollution of industrial areas, although in both countries measures are being taken to overcome these phenomena. Besides, active measures are being introduced especially in the GDR for the reclamation of mountain tip heaps (mainly for recreational parks) and the development of nature reserves. It is very important that everything is being done in the interests and with the active collaboration of the public.

Let us now consider the situation in Poland. This country also experiences severe heritage of the past in relation to the environment. Being a densely populated agrarian country with poor soils, its territory was cultivated and deforested long ago. The two World Wars also caused great damage. Finally, the former mining and industrial regions of the country (for instance, Upper Silesia) were not well-planned and were characterized by a high level of air and water pollution, which were further increased by the intensification of production.

At present energetic measures are being taken to improve the situation. The pollution of the environment is under strict state control, and protection measures are being worked out.

An analogous situation may be found in Hungary, Bulgaria and Romania. The territory of the first of these countries is also heavily cultivated and deforested. For the past 20 to 25 years extensive afforestation work has been carried out and the use of natural resource taken under state control. In Bulgaria the cultivation of the plains was also very extensive; mountain regions (for instance Stara-Planina) were severely deforested long ago. Therefore, this country has inherited severe anthropogenic erosion and badly damaged surface water networks. In these countries all measures are being taken to overcome these unfavourable phenomena (the terracing and afforestation of mountain slopes and construction of reservoirs for irrigation).

Growing industrialization brings as elsewhere air and water pollution. The situation is especially bad in enclosed intermontane basins (for instance, Sofia). The measures so far taken have not produced the expected results although the creation of recreational zones has done much (for instance a mountain park provides Sofia with "lungs").

Finally, in Bulgaria various measures are being taken for the protection of wild fauna which was severely impoverished during deforestation, hunting and fishing in the past. At present hunting and fishing is strictly regulated and the fauna is being restored.

In Romania we encounter the same environmental problems which are under strict state control.

Concerning the Soviet Union besides general information much attention is paid to the European part of the country. As is known this is the most densely populated area of the country and the environment has been especially changed by man. It was here that the Soviet Union inherited severe problems from tzarist Russia; the extensive areas of treeless and heavily cultivated land, subjected to drought and drying winds; the ruined nature of the surface drainage network and widespread ravine erosion; and badly planned industrial centers (St. Petersburg, Moscow, Nizhni Novgorod, Ivano-Voznesensk, Donbas, Baku etc.) with polluted air and water.

All natural resources are nationalized in the Soviet Union. The first decrees stating of the new country's responsibility for nature protection were signed by V. I. Lenin. Reservations were formed and regulations were established for hunting and fishing. The first state programmes were planned for the rational use of natural resources.

However, it proved too difficult to carry out these programmes. Economic dislocation, civil war, severe economic blockade, continuous menace of war dictated the rapid development of the productive forces, the economy and the defence power of the country. The various natural resources of the country were used as a basis for this development, sometimes under severe dictates of economy.

For instance, powerful hydro-electric stations were constructed on the Volga, Dnieper, and Don, thus creating an extensive power base for industrialization although large areas of meadow were flooded and fisheries distorted. Timber-cutting was also increased in the country. However, lumbering had to be carried out in the regions well provided with transport, thus leaving the more remote taiga regions for future use.

The Patriotic war with German fascism wrought new losses and damage, and after its successful conclusion all forces were given over to the reconstruction of economy. But that is all in the past. The socialist system, the Soviet people's labour and the enormous natural resources of the country have made it possible for the Soviet Union to advance from a backward agrarian country into a powerful state with a developed agriculture and other branches of economy. Therefore, it is natural that the latest technological progress has also been made in the USSR and in different forms has affected the environment.

One of the most important tasks in the building of communism is the conservation and improvement of the environment. This task is included in the Programme of the Communist Party of the Soviet Union, and has been formalized at a number of Party Congresses, including the XXIV Congress, and in many of the state plans of the development of the national economy. The necessary measures of implementation are approved by the Soviet people who take an active part in their practical realization.

For instance, various measures are carried out to overcome drought and erosion in the European part of the USSR. A network of protective forest-belts has come into being, extensive agrotechnical land-reclamation and hydrotechnical work for regulating the flow of surface water has been undertaken while reservoirs have been created and irrigation developed to drain swamps and prevent excessive dampness in the territory. In the forest zone extensive afforestation has been carried out and proper forestry has been organized.

Measures are being taken to restore fisheries in reservoirs. Due to the control of hunting and fishing the valuable and rare sable, elk and others have been preserved and their number is at present increasing.

In large cities and industrial centres the struggle against noise and the pollution of atmosphere and water is carried out. Although these problems have not yet been solved for instance in Moscow, considerable improvements have been achieved. For this purpose a number of large enterprises have been transferred to closed water circulation and complicated mechanical, chemical and biological cleansing devices have been installed.

River flow in the European part of the USSR is almost controlled now. At present water transfer is being worked out and takes place from the rivers of the Polar basin to the rivers of the Black and Caspian Seas to improve the supply of water to industrial centers, to develop irrigation and to improve the fishing conditions and stabilize the level of the Caspian Sea.

In summing up this review of the European socialist countries we can see that the main trends in technological process, that increasingly influence the environment, occur here as well as in the capitalist countries. In all these countries demands for natural resources are rapidly growing, giving rise to increased industrial waste, concentration of the population in towns and air and water pollution. The present consequences of industrialization and urbanization in the socialist countries and their effect upon the environment are in part the heritage of capitalism.

At the same time major specific features characteristic of the socialist system are clearly displayed in the present state of the environment and in the development of measures for its conservation and improvement. These features are as follows:

Systematic state control over all forms of industrial and domestic pollution of the environment and the execution of strict measures for its limitation and elimination;

A social policy of organizing recreational zones for use of the working people;

The expansion and execution of various state measures, on a scientific basis, for the conservation of given areas, and for the protection and enrichment of flora and fauna;

The scientific technical and planned transformation of nature with the aim of the rational use of natural resources, conservation and further improvements to the environment.

In the introductory chapter to this volume of essays modern scientific approaches to the conservation of the environment and the rational use of natural resources are discussed. The main research trends resulting from such approaches are outlined. The regional reviews in the volume make it possible to appreciate thoroughly the degree of actuality of the trends discussed in their totality.

GEOGRAPHY AND CONSTRUCTION IN THE FOREST STEPPE ZONE OF THE RUSSIAN PLAIN

by

T. V. ZVONKOVA

The forest steppe zone of the Russian Plain is a territory where extracting and processing industries of utmost national importance, such as the mines and dressing plants of the Kursk Magnetic Anomaly (KMA), the collieries at Tula, the oil-fields of Tataria, the Togliatti-Zhiguli Works, and the factories of the Kama Valley have been concentrated. These industries and urban agglomerations occupy considerable areas of arable land, open forest and steppe. Like the other forest steppe zones of Europe the Russian Plain possesses only limited surface and ground-water resources. Soil moisture is not always and everywhere reliable, and the dissection of the area by ravines and gullies is very pronounced. The southeast of the zone is afflicted by drought and soil deflation.

Rough dissected relief, variable forest cover and humidity are responsible for the lack of association between ecological and spatial complexes which impose constraints upon economic decision-making particularly in the field of industrial and urban development. As in other transitional zones, change in climate over-rides the dependence of biotic factors upon the lithological background in the forest steppe. Thus there are numerous similar small natural areas such as forest-fringed ravines that, while being different geologically and geomorphologically, are largely the same ecologically. This holds true particularly of rough and lithologically diversified slopes which, being indentical in exposure, are similar in regard to soil and vegetal cover. It is true that the ability to substitute one of these complexes for another exists for essentially agricultural purposes such as the choice of arable fields with a view to a simultaneous ripening of crops.

In the eastern and western regions of the zone traversed by the wide valleys of the Volga and Dniepr, the conditions for building are similar over the vast watershed areas and on the wide river terraces.

On the Russian Plain as well as in other forest steppe regions of Europe the disparity between spatial and ecological requirements on the one hand and resources on the other is most conspicuous. These problems of disparity are solved by systematic analyses of such features as the water budget and comprehensive surveys of economic and natural resources.

The problem of resource disparities arises most frequently in regions where the extractive industry is located because any plan of work is determined by available reserves and the configuration of the areas where these are found. In the forest steppe zone the location of raw materials in many instances precludes the setting up industrial enterprises of high water consumption. Not infrequently, one must decide between supplying such a region with water from afar or restricting the scope of building. Such decisions will have to be made over the setting up of iron ore-dressing plants based on the deposits of the Kursk Magnetic Anomaly (KMA).

On the area of the KMA the rapid development of mining, smelting, the chemical industry, metal processing, mechanical engineering and construction materials require not only reserve building sites, but water resources as well. The water supply of the KMA area, however, already faces considerable difficulties. From an annual precipitation of 665 mm, 82 per cent is lost to evaporation. Of the remainder one quarter goes to recharge the ground water and three quarters discharges into the surface stream network. In the long run, half the surface water will be retained for arable cultivation, but the rest will be insufficient to satisfy the needs of industry and population. Water expenditure will rise mainly because of a rapid increase in consumption at the opencast mines of Lebedinsky, Stoilensky and Mikhailovsky, in the cities of Kursk and Belgorod for the replenishment of storage basins and reservoirs and, in particular, for irrigation systems. This will disturb the regime of the ground-water table over tens of thousands of square kilometres in the Kursk, Belgorod, Orel and Briansk regions. At present, there are only a few local areas characterized by economic needs in excess of water resources. Nevertheless, the production of iron ore in the KMA area has increased by 44 per cent over the last five years alone. Subsidence around surface mines and large cities is expected to go on and is expected to double in area by the year 2000. This circumstance will limit the building of factories of high water consumption such as thermal power stations, and heavy metallurgical and integrated chemical works.

Some economists consider that modern telecommunication facilities will almost entirely eliminate the problem of distance in managing industrial enterprises. Whereas in early times large distances used to hinder industrial organization and lines of communication in particular, nowadays the effect of distance is altogether different. At present, when new sites are deficient and building projects are becoming congested, production is handicapped not by great distances, but by the close spacing of industrial, urban and recreational facilities. In industrial regions these distances are defined essentially by factors of health, by the depth of surface mines and water-bearing horizons supplying industrial plant and urban localities. New building projects are feasible in certain regions of the zone at distances up to 15 to 20 km from deep surface mines.

The forest steppe of the Russian Plain yields more than 60 per cent of the country's cereal output at a relatively low unit cost. Accordingly, the best arable lands are characterized by high yields of wheat and sugar beet from typical chernozem soils on the vast areas of subdued relief around watersheds and high valley terrases. At the same time, these are potentially suitable sites for building projects. This is why thousands of hectares of interfluve land of high fertility are built on, carved out for surface mines and buried under spoil-heaps. The future extension of housing construction and surface mining projects will lead to additional losses of arable land. The conflict between industry and agriculture, a phenomenon characteristic of technologically highly developed countries, is most conspicuous for large industrial complexes being developed in regions suffering from a shortage of free land. By way of example, let us consider the KMA and the Togliatti-Zhiguli Works. Over the KMA territory alone, during the exploitation of the ore deposits, it will be necessary to deprive agriculture of six times more land than has so far been used by the mining complex.

A large project is envisaged in the Ivnya-Shebekino district, where more than 90 per cent of the high grade iron ore is concentrated. In this district a new city to be built near the Yakovlevsky deposit will occupy more than one million hectares of former arable land.

Near the Zhiguli National Park the Volzhsky Automobile Factory, the largest in Europe and a new city are being constructed. On account of the high concentration of population around the factory and the loss of arable land and scenic amenities, there is an urgent necessity to set aside land for recreation, agriculture and pasture. When the construction of the factory and the auxiliary enterprises have been completed, no further land will be available for additional big building projects. Further expansion of the industrial complex will only be possible in a northeast direction, provided that the city of Togliatti can be protected from the industrial air pollution caused by the prevailing northeasterly winds.

Industrial and housing projects in regions similar to the KMA and to the Togliatti-Zhiguli area are only possible in the context of complex regional and land use planning.

The problem of spatial disparities between industrial and agricultural production can be similarly solved by locating building projects in the low-fertility parts of the zone, where the yield of bread grain crops is lower than 10 to 13 quintals per hectare, i.e. in areas with relative relief coefficients of 0·3 or so, slope angles of 6 to 11°, and denuded and eroded soils. In these cases, however, project sites are selected according to principles that deviate from optimum standards and the cost of site preparation and, consequently, of construction is increased.

Since building projects are unavoidable on the highly productive lands of the zone, it is the grey forest soils that should first be utilized. Where a depression of the ground-water table occurs as a result of building, crop yields will decrease more rapidly on these soils than on chernozems which are more highly water retentive.

The problem of disparities between industrial projects and agriculture should be solved not only by spatial redistribution, but by changing the potential of nature particularly by increasing arable crop yield. In the forest steppe this is possible, thanks to the organization of irrigation land on the southern steppes using canalization waters from industrial and housing developments. Other measures include the reclamation of eroded soils, and general increases in the standard of agriculture.

Another intriguing problem of the area is the covariance of building denities and the ecological possibilities of the landscape. The landscapes of the forest steppe are not only dynamic, but unstable against physical and mechanical attack. This is due both to the presence of loessic sedimentary rocks, light and partly grass-covered soils and to the high density of buildings and the large population. For instance, in some districts of the highly urbanized region of Tula 70 to 75 per cent of the population inhabits between 10 and 15 per cent of the surface area. The loessic sediments of the interfluves are particularly unstable in areas with a fluctuating upper level to peak floods. The same holds true of the banks of the large reservoirs of Kuybishev, and Kama, where the ground-water table is unstable, ground subsidence is still at work and no definite bank-line contour has yet been established. The foundations of heavy industrial plant and multi-storey dwellings constructed there, are liable to deformation.

As a result of human action (trampling and motor traffic on the grass cover in the absence of roads) the sandy loessic and argillaceous ground surface rapidly loses its compactness and is eroded. Where the potential capacity of the natural complexes is exceeded, first the trees disappear, leading to the formation of steppe (the appearance of Gramineae at grass level), and finally to the disassociation of old assemblages and the appearance of steppe bush and patches of denuded soil.

On account of the shortage of pasture and excessive exploitation, the slopes of forest-clad ravines will be devastated and transformed into steppe. Since this process and the dissociation of the natural assemblages are particularly intensive in regions of large-scale industrial and housing development, reduced population density norms are necessary for the protection of the landscape (e.g. for forest-clad river terraces, a value of 6 to 8 persons per hectare, one and a half times lower than the present figure, is desirable).

Measures for protecting nature are now an integral and obligatory part of regional planning projects for developing areas. During the last few years projects of this kind have been developed and implemented in the regions of Kuybishev, Kursk, Belgorod and in the Autonomous Soviet Socialist Republic of Tataria with the cooperation of the Faculty of Geography of Moscow State University.

In regions with important extractive industries the problem of land reclamation arises. The presence of very important iron ore and coal deposits in the central zones of the forest steppe has influenced the development of the entire network of small workers' villages and towns located near mines, quarries, and mineral-dressing plants. In the case of high building and population densities, the impact of open spoil-heaps is particularly drastic. With increasing housing and opencast mining developments, the problem of recultivating damaged landscapes becomes more and more timely.

Landscape reclamation projects in the mining districts of Lebendinsky, Stolensky and Mihailovsky (in progress) have revolved around sylviculture and the restoration of arable cultivation. According to the plans, spoil-banks close to the collieries of the Tula region as well as the poorly forested SE regions of the zone are firstly to be reforested. On the opencast mining waste tips in the north, on grey and sandy forest soils a stable and aesthetic forest landscape is already being developed, by planting oak, beach and pine species typical of the forest steppe. Conceived three-dimensionally, the forest landscape affords protection from erosion and dry wind action, and food (wheat and vegetables) and fodder production (pasture intervening between forest belts).

The complexity of creating a forest landscape on mining waste is due primarily, to general deforestation through history, to active erosion of the rough and steep slopes of the spoil-heaps, and to the toxicity, low humidity and high thermal capacity of the soils. Owing to the low suitability of mining waste for vegetation growth as reflected in the low percentage of saplings taking root, the length of time necessary for complete landscape restoration is 15 to 20 years. Hydraulically-formed spoil-heaps and waste are particularly unstable, which renders dangerous any construction on them.

A scheduled utilization of spoil-heaps for agricultural purposes is not always possible because of the distribution of the land amidst industrial plant and the continued working of mines in the neighbourhood. It is more reasonable to return damaged land to agriculture in the southern part of the zone, where are found deep, leached chernozems of high fertility. The high recultivation cost can be reduced by using not only specially pre-stored chernozems for burying toxic soils, but waste-rocks of high humus content as well; e.g. Jurassic loess and sandy-clay rock, very close in humus content (4—5 per cent) to the grey forest soils.

Attention should be paid to the hydrological processes of soils for estimating and forecasting potential damage caused by mining in agricultural regions. Methods for this were developed by the Polish scientist Cz. Zulawski who believes that "damage to soils is in direct proportion to the index of change in the hydrological regime and inversely related to the retention index characterizing the capacity of the soils to hold meteoric waters".

In terms of the USSR land-protection legislation of 1969 and 1970, in regions of heavy mining and large-scale building, opencast mining must be modified along lines of selective extraction and both mines and waste must be sited on low-grade land. Other methods for the efficient utilization of the land are also to be developed. At the same time, laws that protect the health and satisfy the spiritual and aesthetic needs of the inhabitants of a socialist country should be given preference, as a general rule, to economic considerations, however high the costs involved may be.

Controlled mainly by the presence or absence of natural resources, irregular building in the forest steppe has produced two types of area:

(a) areas with low building density and land devoted mainly to agriculture or forestry. Damage to contemporary natural complexes in these areas is of relatively low importance. If it is necessary to erect buildings in such areas, their sites should be selected on the basis of potential change to the natural environment;

(b) areas densely built-up and frequently over-populated, with arable land, forests and meadows heavily transformed by Man's activities but where a relative equilibrium exists between the environment and technology. Well-reasoned programmes are necessary with regard to major building projects and the reconstruction of old buildings.

Two provinces can be observed in the forest steppe of Russian Plain, the central and peripherial provinces (western and eastern), based on the combination of areal types and the natural factors determining the conditions for siting industrial plant and urban developments. Despite the fact that the Middle Russian Plateau and the Oka-Don Depression are orographically and genetically heterogeneous, they belong to the central province and the conditions for sitting and building industrial plants and residential areas in these regions are thus similar. As compared with the east and west of the zone, the central province exhibits distinctly the disparity between the need for space, ecological protection and raw materials on the one hand, and existing possibilities, on the other. This can be explained by the predominance in this region of agriculture (up to 80 per cent of the area is occupied by arable land), by the absence of large undisturbed areas with sufficient water supplies for sites of large enterprises of high water consumption as mainly the upper reaches of rivers are found here. Densely built-up areas and landscapes damaged by large-scale industrial development (the Belgorod, Kursk and Tula regions) and numerous quarries (the Tambov and Voronezh regions) occur more frequently here than in the other regions of the zone. Since the bedrock, differring in both age and lithology, is covered almost everywhere by a thick layer of loess, technological and geological conditions are similar throughout the territory. Because of the general water deficiency of such areas, in drafting future projects the planners have to designate local areas where the aforementioned enterprises and urban developments are prohibited unless measures to ensure the supply of water can be taken. This would refer mainly to areas where the ground-water regime has been disturbed. In such areas in the case of the necessity for large-scale building, a transference of water between for example the Psiol, Seim and Oskol river basins should be provided for.

In areas of water shortage the problem of setting up enterprises with low water consumption should be resolved by utilizing local surface and ground-water, especially by redistributing diverted water, by collecting spring water in natural and artificial storage basins, by diverting mine water into river beds, and by re-cycling sewage water after purification. Similar schemes have been designed and implemented in, for instance, the mining districts of the Kursk region. The storage basins there containing nearly 1·5 per cent of the water resources of the region, supply water for sugar refineries, distillaries, and dairy produce. Eight additional reservoirs are being constructed for industrial and communal purposes.

As a result of pumping water from mines, the ground-water table and the share of ground-water flow in the recharging of rivers have dropped. Although the annual average amount diverted has not yet been changed in the long run, it is quite possible that in seasons characterized by the lowest water level the upper reaches of rivers may run dry. River water flow and ground-water recharge may be increased by diverting water pumped from mines into the river network. Ground-water reserves should contribute to waters infiltration into reservoirs, and storage basins. In addition, new methods of mine drainage such as freezing the rocks lining the shafts to be sunk at Yakovlevsky in the KMA should also be developed.

Water redistribution of this kind may lead to substantial fluctuations in the ground-water table and to periodic wetting of the loess at foundation level, which may cause the deformation of rocks at the base of structures as a result of subsidence.

In the long term, the possibilities for selecting building sites in areas of poor water supply will be limited. Relatively favourable conditions will only be obtained for agriculture and for enterprises requiring few buildings and simple communication links.

The peripheral province includes not only the Volga Plateau and part of the Volhynian-Podolsk Plateau, but also the vast terrace plains of the Volga and Dniepr rivers and their tributaries. These areas are characterized by the large-scale storage of water which accumulates in part within the zone — namely the Volga, Kama and Kremenchug reservoirs. Along these storage basins important industrial plants are being built, such as the motorcar factories beside the Volga and Kama reservoirs.

Because of the impoverishment of industrial mineral resources and a decrease in the role of the extraction industry, the site association between building construction and natural resources will decrease in the long term. This circumstance suggests that the influence of natural factors on the location of industrial plant and other facilities may fall. In other words, the choice of possible areas to be built in will be enhanced. It is true that in the forest steppe processing industries will depend even more on water resources. Nevertheless, as very few areas, suitable for the location of large enterprises with high water consumption are available, a reduction in large-scale building operations is to be expected in the years to come.

This trend towards the decreasing influence of urbanization upon the natural environment of the zone may be somewhat hypothetical. It is possible that the weakening of ties between new sites for building and the availability of natural resources and favourable natural conditions may increase their dependence on existing combinations of natural and technological complexes.

It seems that modern plans for high-investment building in the forest steppe should envisage a low number of projects of national significance. At the different planning levels the following principles should be adopted:

(a) the limiting of the number of projects of high water consumption during the drafting of general building projects, particularly in the southern areas of the zone;

(b) the divertion and purification of industrial waste and communal sewage and the restoration of damaged landscapes to the level achieved in district study projects;

(c) increasing the supporting strength of the ground surface and improving the stability of buildings during the drafting of projects for substandard surfaces.

THE INTERACTION BETWEEN THE GEOCOMPLEXES OF THE RUSSIAN PLAIN AND TECHNICAL SYSTEMS

by

K. N. DYAKONOV, L. F. KUNITSYN and A. Y. RETEYUM

A characteristic trend in many branches of science, including geography, is a rising interest in the study of the processes of man's interaction with his natural environment. In recent years our knowledge of various aspects of this old but ever more pressing problem has been considerably extended. At the same time, as a study of the literature indicates (in particular the reports presented at the recent UNESCO conference in Paris*), treatment of the problem as a whole has not been given adequate attention in relation to individual regions and countries.

This situation is largely due to the absence of a proper methodological approach. At present a number of problems are being successfully resolved by ecologists, clarifying the place and role of human groups in ecosystems. Studying the interaction of man and nature, geographers striving to formulate measures for the rational utilization of resources and the transformation of environmental conditions, have introduced terms like devastated landscape,** and developed landscape; but in view of the vagueness of the meaning of natural landscape, the concrete integration of abiotic, biotic, and anthropogenic elements often proves to be unsatisfactory.

Looking into the causes of disturbances in the processes of nature, it can be stated that the main one is the means of production, i.e. machines and technology. The interaction of various buildings and structures, equipment, devices and installations, with the environment justifies speaking of geotechnical systems embracing both these artificial bodies and the physical, geographical entities falling within their sphere of influence. Study of such heterogeneous formations, and of the role of planning within them, is an important task of geography (Khilmi, 1963; Preobrazhensky, 1967; Kunitsyn, 1970; Saushkin and Smirnov, 1970). The present work is a first attempt at a general characterization of geotechnical systems from data relating to the Russian or East European plain.

In order to study the objects concerned, it is necessary to divide them into groups. The classification suggested by Reteyum (1971a) springs from the assumption that the principal property of geotechnical systems is their leading (technical) role in the exchange of matter and energy between society and nature.

Among all the diverse techniques that man has developed, the means of extraction stand out above all others, i.e., the methods and equipment used

* Intergovernmental Conference of Experts on the Scientific Basis of the Rational Use and Conservation of the Resources of the Biosphere. UNESCO, Paris, 1968.

** German—Landschaft, Russian—ландшафт, природньий комплекс in obtaining materials, power, and information from the environment. These are subjected to processing of various kinds in their passage from nature to society. In these processes of interaction between society and nature, systems belonging to a third group namely services (in the broad sense of the term) occupy a special position.

Servicing techniques are of two kinds: (a) those especially designed to change physical conditions; and (b) those not directly designed for such purposes. Those of most interest to us, of course, are the active means of affecting nature. Among them it is necessary to distinguish open and closed systems in Bertalanffy's sense (1962).

Closed systems affect the environment without returning matter to it; they may be controlled or uncontrolled. Uncontrolled systems are static in character and either block a flow or fulfil an opposite function by creating conditions that accelerate a flow, sometimes changing its direction in doing so. Thus uncontrolled systems may be divided into two groups, namely barrages and drainage systems. The other type of closed system, called regulating, is a combination of barrages and drainage structures operating at different times. Examples are gates or locks in barrages, and pressureless irrigation systems.

The next two groups, active servicing techniques, differ in principle from all others in that they act on the environment by returning matter, energy and information to it. This quality of open systems is new and makes fuller control of natural processes possible. The objects involved differ in the degree of their human domination of nature, and for that reason are divided into controlling and determining (directing) systems. Determination here means full control of the parameters of nature in a limited space, for example, as created by means of greenhouses, phytotrons, and similar structures.

Technology stands opposed to the environment of various natural systems. The systems most studied today among the heterogeneous formations comprised of geographical elements (rocks, air, water, animals, plants, microorganisms, and non-living organic materials) are ecosystems. It is a widely held view in this context that ecosystems are unique, actually existing geographical objects. But there is reason to believe that such objects may be formed (or created) not only by organisms but by other elements, above all by water, but also by air and rocks, which in certain conditions possess mobility and very high activity. Organic geosystems, in which the parts (local combinations of elements) are determined by the structural whole, are better called geocomplexes (Reteyum, 1971b). Geocomplexes include, for example, the systems formed by the action of river, marine, and lake currents, glaciers, landslides, lava streams, and other types of flow. One of the commonest physical units of this kind on the Russian plain is the system formed by channelled water flows (streams and brooks). The smallest units of the first order, have an average area of around 0·5 sq.km (Rzhanitsyn, 1960). Geocomplexes of the 15th order have the largest dimensions, and through consolidation they form the Volga and its tributaries, and drain an area of 1·4 million sq.km in which 30 per cent of the population of the USSR is living.

It must be emphasized here that it is necessary to know how the physical environment is organized in order to develop a theory of the rational utilization of natural resources.

Passing to the characteristics of geotechnical systems, we would first point out the quite different intensities of interaction between the artificial and natural parts. An important distinction is that between organic systems, in which the technical and natural elements are so joined that they comprise a self-regulating whole, and all other systems.

We shall first examine the basic features of inorganic geotechnical systems. The bulk of the material utilized by society comes from mining and the extraction of minerals. There is much in common between the geotechnical systems based on the employment of equipment designed for the direct extraction of solids, liquids, and gases from the interior of the earth. In essence, the causes of the shifts in the environment arising from the application of technology are always the same — the redistribution of matter and energy and the resulting disturbance of the equilibrium between the extracted elements and those that are left.

The mining of solids is usually accompanied with changes in the direction and rate of movement of underground waters, a lowering of their level (expressed as a rule in a drop in biological productivity), disturbance of the regime of surface streams, subsidence, and the accumulation of mass waste and tailings. These geotechnical systems are typical of the Donbass, Pechora coal basin, Kursk Magnetic Anomaly, and other districts with coal measures, deposits of shale, iron ores, and building materials.

Petroleum is extracted in immense quantities from beneath the Russian plain; production is mainly concentrated in the Kama Valley, and the Komi ASSR, where the wells are having a marked effect on the environment as a result of the loss of oil and its replacement by water.

Water-extracting installations are becoming more and more common. The main source of water — yielding more than 90 per cent of the total extracted — is surface run-off. The bulk of installations are small; the biggest systems include the pumping station of the Moscow-Volga Canal (extracting up to 100 m^3/sec), and the pumping stations of the Dniepr-Krivoi Rog and Northern Donets-Donbass Canals (maximum productivity 35 and 27·5 m^3/sec respectively).

The pumps installed on small rivers affect a wide zone, in which a number of negative phenomena are to be observed resulting from a reduction in flow. The pumping of an excessive quantity of underground water in a number of cities is causing an increase in the mineral content of the water and subsidence of the ground.

Some geotechnical systems are being formed in the course of extracting information of one kind or another from the environment, especially in prospecting for minerals.

So far we have considered the geotechnical systems formed by structures and undertakings that yield a flow of material, power, or information from the environment to society. But there is another group of extractive techniques which rework and transform the material obtained with the aim of abstracting power, necessary chemical elements and compounds from it. These include, for instance, various power installations, steel works and fertilizer works.

Thermal power stations play a leading role in the production of power. Their operation is associated with intensive mass heat exchange with the environment, which is the cause of subsequent changes. The Konakov power station, for example, which has a rated capacity of 2400 MW, pours up to 80 m^3/sec of warm water into a bay of the Ivankovo reservoir (capacity 1·8 million cu.m) thus raising its temperature by between 4° and 11 °C. As a result a special chemical regime has been established there with a significant rise in biological productivity (Maksimova, 1970; Nikonorov and Nikonorova, 1970).

The volume of the sphere of influence of the large steel works concentrated in the south of the Ukraine is measured in cubic kilometres.

The special character of geotechnical systems in which the means of processing extracted materials play a leading part, depends, in general, on the same factors as in the previous group, that is to say on exchanges with the environment. Features of this type are distributed over the whole territory of the Russian plain and are very numerous (especially in industrial centres) and diverse.

Servicing techniques not intended to transform nature, interact in the least specific way with the environment. From the physical aspect, their effect may be the result, firstly, of purely mechanical action on mobile geographical elements (water, air, animals), and secondly of the mutual exchange of matter and energy.

Now let us pass to a consideration of geotechnical systems owing their origin to active interference with the course of natural processes.

The building of barrages is undoubtedly one of the simplest ways of affecting the environment. These structures, made of reinforced concrete, stone, wood, and other materials, make it possible to reduce or completely suppress the flow of both abiotic and biotic matter and energy, on land, in the water, and in the air. Barrages are divided into gated and non-gated, linear and areal, and single and multiple types.

The strongest effect is exerted by structures that block the system-forming flows of geocomplexes; thus the features of the geotechnical system are particularly clearly expressed. Dams are the most common type of barrage. Many of the large rivers of the Russian plain have already been dammed or soon will be; on the Volga there are eight of these structures, on the Kama three, and on the Dniepr six. In the south of the area dams are very common on small rivers. Apart from the disturbance of natural flow regimes over areas varying from thousands of square metres to thousands of square kilometres, the properties of the ground water and lower layers of the atmosphere are altered in the sphere of influence of dams, the extent of the zone of hydrogeological and climatic influence usually being of the same order as that of the support zone. The raising of the water table to a level of two to five metres below the surface leads to a transformation of the soil and sequential changes in the vegetation and animal populations, accompanied by either a reduction or an increase in productivity (Reteyum, 1968; Dyakonov, 1970). This part of the sphere of influence of large dams may be close in terms of area to the extent of the reservoir and may sometimes exceed it (Emelyanov, 1966).

In the other group of uncontrolled geotechnical systems drainage works of various kinds play the leading role. These are built in places where it is necessary to raise the rate of flow of ground and surface water. The overwhelming majority of drainage networks serve agriculture and forestry. In addition to improved growth of crops and forests within the limits of a drained area, a number of negative features are sometimes experienced, namely temporary drying out of the soil, deterioration of the heat regime of the soil, and a rise in the occurrence of frost.

The number of drainage geotechnical systems on the Russian plain has increased rapidly in recent years and their area at present amounts to 100,000 sq.km.

The next three groups of geotechnical system belong to the category of controlled or regulated systems, i.e. systems in which definite optimum conditions are maintained in both the technical and natural parts, in accordance with environmental conditions and the requirements of the industries served.

The simplest controlled structures are regulating ones. Their use, as noted above, enables natural objects to be affected without returning matter to them. They bring about a redistribution of mobile geographical elements in time and space. Most often it is water flows that are affected. Two forms of regulated hydrotechnical system may be distinguished, if somewhat arbitrarily, namely linear and areal forms. Linear systems control channelled flows, producing within the natural channel only a redistribution of flow in time, or, in case of artificial channels, redistributing the flow in space. The scale of the consequences of regulating the flow of the large rivers of the plain is enormous; long-period artificial variation in volume and flow produces not only significant shifts in the ecosystem of the river but also of the flood plain and estuarine regions. Above the structures it leads to sharp changes in the processes taking place in the reservoir and along its banks. Areal hydrotechnical systems are designed for irrigation. In the RSFSR and the Ukraine energetic measures have been taken to create a large number of new systems of this type, with the result that they now cover an area of more than 20,000 sq.km in the south of the plain.

So far there have been only a small number of biotechnical systems on the Russian plain in which populations of useful animals are subjected to regulation by means of artificial habitats, nesting places, or sleeping places.

Fuller control of natural processes is provided by open technical systems returning matter and energy to the environment.

The overwhelming majority of regulatory geotechnical systems are designed to control water flows. The regulation of flows for purposes of irrigation and watering is distinguished from that in which volumes of water are displaced against the force of gravity. According to the extent of their effect on the soil and atmospheric regimes, the latter are divided into sprinklers of periodic action or special impulse operation. Sprinklers are also employed to control the chemical composition of the soil through the addition of fertilizers to the water.

Other members of this group of controlled system are biotechnical systems with regulated populations of animals. They are made possible by breeding. The most important form today is the control of populations of valuable fish. The main fish-breeding districts are in the Azovian and the Caspian Seas. In the lower reaches of the rivers running into these seas there are more than ten sturgeon and salmon hatcheries and a number of fish farms specializing in raising the fry of other fish.

The purpose of the last group of systems is to create fully controlled conditions in a definite volume of the biosphere, independent of the state of the environment. Their determining structures are based on a given level for certain indices (temperature, illumination, concentration of O_2 and CO_2, and salinity). Their numbers are insignificant.

The geotechnical systems outlined above may be considered elementary since they consist of a single technical object. Actually, technical structures and installations of various type are usually linked together to form diverse combinations. The connections are usually dictated by the interests of production and industry, for which extractive, processing, and operational or servicing systems are united. The characteristics of the combinations so formed, which make possible a real picture of the interaction of society and nature within economic regions, form an interesting problem that can be resolved on the basis of Kolosovsky's theory of power-production cycles (1947) and Komar's views on resource cycles (1969).

From the study of the conjugation of extractive and servicing (processing) technical systems on the one hand and natural features affected by them on the other, it can be affirmed that they sometimes form a special category of heterogeneous combinations having the properties of an integral whole (which we have called geotechnical complexes). One of their indispensable elements is some activity influencing the environment, which is employed to regulate, control, and direct natural processes. The role of control centre is performed either by man or by automatic instruments.

Two classes of geotechnical complex are distinguished — subordinate (or dependent), and autonomous.

At the entry of subordinate complexes on the path of a natural flow there are regulating devices; therefore they are dependent on the environment. The degree of dependence is determined by the composition of the system. Let us compare two hydrotechnical complexes as an example; one takes water by simple diversion, while water passes through the second from a reservoir created by a dam. Clearly the second presents opportunities for limiting the effect of the environment.

Hydrotechnical complexes with reservoirs are the largest and one of the most common types on the Russian plain. They mostly accompany power stations, i.e. with energy extracting installations. The study of their role, interconnections and their relationships with the environment indicates that here we have an integrated self-regulating system.

In the south of the Russian plain there are also several subordinate hydrotechnical complexes of agricultural significance. As a rule they are quite complex, since, in addition to their main elements (areal and linear regulating structures and irrigated fields), they include many different technical systems extracting information (water-measuring points for example) or ancillary structures (barrages of various types and settling areas).

Autonomous geotechnical complexes are distinguished from subordinate ones in that the regulation of natural processes is here affected by controlling and directing structures and instruments. The return of matter and energy to the environment in these open systems presupposes preliminary extraction from elsewhere, performed by a special extractive installation. The existence of such an installation makes the whole complex less dependent on the environment and, at the same time, more integrated.

Autonomous geotechnical complexes are more varied in character than the subordinate ones. They may be divided into two groups — regulating systems and directing (fully controlled) systems.

The bulk of the first group consists of hydrotechnical complexes in which water-raising installations play a leading part. They almost all have an agricultural purpose. When the projects now under construction are completed there will be a great many large systems of this type in the arid Transvolga region.

The functioning of existing biotechnical complexes has inherent features arising from the difficulty of regulating animal populations.

The most developed geotechnical complexes are greenhouses, phytotrons, and similar objects in which full control of the conditions is achieved.

The complexes described here are only part of more complex formations. Two types of complex of the first order can be distinguished. One is the cascade in which complexes of the same type employ a flow of water one after the other. On the Russian plain several exist; we shall cite only the immense Volga-Kama cascade of hydrotechnical power complexes. The following figures will give an idea of its scale (Mikhailov *et al.*, 1969):

total useful volume of reservoirs	$80{\cdot}0\ km^3$
volume of earth structures	$0{\cdot}8\ km^3$
volume of concrete structures	$0{\cdot}3\ km^3$
electricity generated	36,000 million kWh (approximately)

The other type of combination is an aggregate (association) of interconnected complexes of various kinds. An example is the group of power, agricultural and water-supply hydrotechnical complexes based on the Kakhovka reservoir on the Dniepr.

When united, combinations of geotechnical complexes constitute in turn more complex systems, both uniform and diverse. The uniting of individual hydrotechnical power complexes and cascades into power networks by transmission lines is widely developed. A number of large major formations of this type exist on the Russian plain, and at present a single power grid is taking shape that will gradually constitute a gigantic geotechnical system. When it is completed it will be feasible to select a more effective variant for utilizing natural resources, in particular, through taking into account both synchronous and asynchronous variations in the flow of rivers.

The heterogeneous systems of the Russian plain include the aggregate of associations of hydrotechnical complexes fed by the water of the Dniepr.

The existence of diverse and increasingly complicated links between various geotechnical systems is raising problems of coordinating their regimes in order to optimize them. Geographers have an important and responsible contribution to do in solving this problem.

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THE ALTERATION OF THE PHYSICAL LANDSCAPE BY HUMAN ACTION IN THE ESTONIAN SSR

by

E. VAREP

The changes that take place in the natural environment as a result of human interference constitute a complicated process, certain aspects of which are still imperfectly understood. Man modifies his natural surroundings most of all by his economic activity, but we must also take into account all the other forms of human activity that act upon the environment. Here an essential part is played not only by the type of economy and the level of development attained by technology and the general process of production, but also by the structure of social life, specific features of historical evolution, ethnographical relationships and various other factors.

Estonia, the northernmost of the Soviet Baltic republics, has an area of only 45,215 sq.km, which constitute a bare 0·2 per cent of the entire territory of the USSR. The country belongs to the northern part of the mixed forest zone. Nevertheless, the climate of Estonia, due to its situation on the shore of the Baltic Sea, is relatively mild and of maritime character. Its surface structure, mainly of glacial and marine origin, is varied. It exhibits a wide diversity of landscape and as a result the exploitation of the land assumes strikingly different forms, of which the basic features were often determined in the distant past.

North Estonia is for the most part a limestone plateau ending abruptly at the steep edge of the Baltic Glint (Fig. 1). The plateau bears in general appearance a comparatively even, smooth character. This impression is produced by the level stretches of calcareous rock, often intersected by underground streams and other typical Karst phenomena. The carbonate soils distributed over the limestone bedrock of the Estonian Ordovician and Silurian outcrops are rich in humus and favourable in structure, but frequently desiccated during the dry season. The proportion of cultivated land is small (ca. 25 per cent), but the abundance of grasslands has created favourable conditions for the development of dairy farming, which has been further stimulated by the proximity of Tallinn and other industrial centres.

The North-Estonian Plateau was densely populated already in the distant past. The population of the countryside is still relatively dense, and in addition a large number of urban centres have sprung up during the modern period. In the vicinity of Tallinn there are numerous industrial and residential outgrowths. In the north-east a remarkable group of young urban settlements has come into being in the mining and industrial region of the oil-shale basin, with its centre at Kohtla-Järve. The historical city of Narva has also, notwithstanding its greater age, become integrated with the area.

The *moraine plains* are the most common landscape type of the interior.

In the northern part of the country this type of countryside dominates the Pandivere Uplands, but it is also characteristic of the Central Estonian Plain. Here we have wide undulating plains, scattered with occasional small knolls and glacial ridges. A fertile calciferous moraine layer is spread over the limestone floor, which outcrops at only a few points. The predominant soils are fertile leached carbonate derns, which rank among the best in Estonia. The vast expanses of level or undulating arable lands create outstandingly favour-

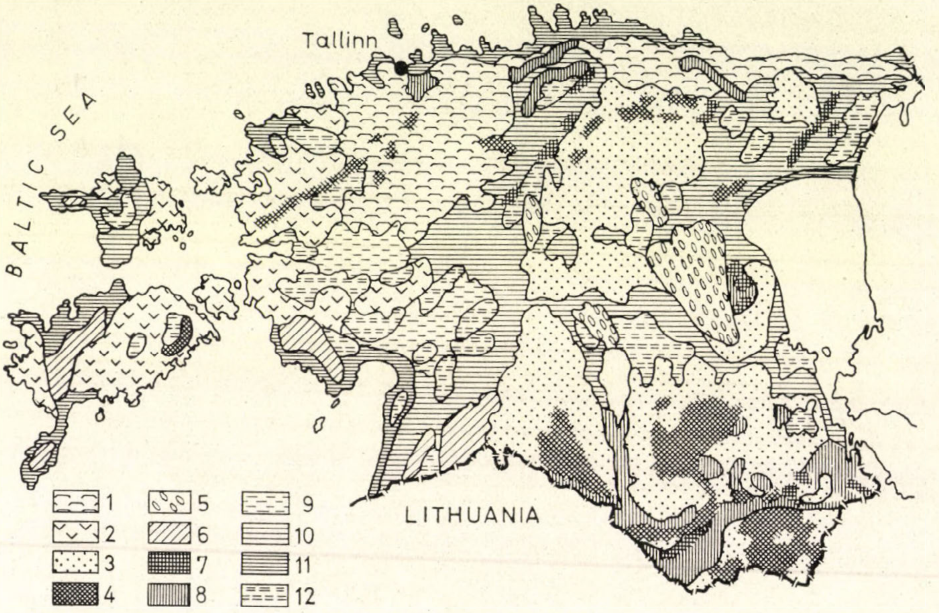

Figure 1. The landscape types of Estonia

1 — Limestone plateaus; 2 — Limestone plains; 3 — Moraine plains; 4 — Moraine downlands; 5 — Drumlin areas; 6 — Wooded elevations; 7 — Kame areas; 8 — Sandy heathland; 9 — Areas of sedimentary clays; 10 — Forest-covered lowlands, sites of former glacial lakes; 11 — Sandy littoral and dune-land; 12 — Bog and fens

able conditions for agriculture, and well-nigh half of the surface area is under cultivation. Taken as a whole these areas are the most profitable agricultural districts in Estonia.

In South Estonia the moraine plains are widely distributed in the Sakala Uplands and in South-East Estonia, especially in the vicinity of Tartu and Pölva. In South Estonia the bedrock consists of Devonian sandstone, outcrops of which are to be found at many points along the river valleys and on the banks of lakes. The plains are intersected by deep old age valleys. In some localities the countryside is dotted with small flattened drumlins running mostly from north to south. Most of these areas are under cultivation and densely populated, especially in the vicinity of the towns of Tartu and Viljandi. For centuries these areas have formed one of the most prosperous districts in Estonia and they still retain their prominent position in agriculture. Urban types of settlement are plentiful, most of them being minor centres of local industrial development.

The *drumlin* landscapes are especially characteristic of the central part of Estonia. The Vooremaa Area, situated north of Tartu, is one of the most typical drumlin landscapes in the world, with its elongated hills stretching from north-west to south-east. Most of them are from 2 to 5 km long and up to 25 m high, though individual drumlins may attain a height of 50 m or even more. They have an argillaceous moraine cover, and the greater part of the surface is cultivated (tilled land about 40 per cent). The interstitial troughs contain lakes, swamps and shrubby meadows. A few patches of woodland clinging to the flanks of the hills are all that remain of the one-time extensive forest cover. Both the network of communications and the settlement of the countryside have been determined mainly by the salient elements of the surface relief. The long, straggling villages are usually situated at the foot of the slopes.

There are other drumlin landscapes in Estonia, e.g. the Türi Drumlin Area, which are similar in all essential respects to the Vooremaa country, but on a reduced scale, the drumlins being smaller and lower, and there are no lakes.

A hilly moraine landscape dominates the Otepää, Karula and Haanja Heights in South Estonia. This is the most picturesque part of Estonia, remarkable for its variety. Here the moraine hills with their rounded summits present a surface relief of great natural beauty. In the central part of the Otepää and Haanja uplands the height of the moraine hills attains, and occasionally exceeds, 50 m. On the periphery of the area the hills are smaller, but the relief is no less diverse. The extreme variety of land-forms is enhanced by the unusually broken and chequered character of the glacial deposits and the distribution of the soils. On account of the steep gradients the soils on the flanks of the hills have been to a large extent eroded, and as a result these surfaces are far less fertile. As a general rule the steepest parts of the hillsides are forested, and their agricultural utilization is attended by serious difficulties calling for the application of special agrotechnical devices. On the other hand, the intermediate hollows are occupied by numerous lakes and swamps, most of which are relatively small in extent. As a result the cultivable land is parcelled out and dispersed in small units, and the mechanization of agricultural labour is rendered extremely difficult.

The rural settlements in this type of countryside are extremely diffuse, and small hamlets and scattered farmsteads were until quite recently the general rule. The main arteries of communication avoid the broken hilly country, with the result that there are no large settlements of an urban type. There are, however, many small local centres which have developed into popular tourist resorts. The exceptionally favourable conditions for winter sports in these localities have attracted constantly growing numbers of enthusiasts over recent years.

Kame landscapes (Kameslandschaften) are characterized by groups of low glacial mounds with sandy surfaces. These localities are mostly covered with forests but here and there small settlements are found, the inhabitants of which are commonly engaged in forestry. In the past these areas were more densely populated, and in many places we can trace the sites of ancient settlements. The kame areas are sometimes rich in lakes and are of outstanding natural beauty (e.g. the environs of Elva).

The *sandar* areas of Estonia, originating from the end of the Glacial Period, are mostly represented by pine covered sandy heaths, which are common in all parts of the country. One such plain stretches south of Tallinn for about 20 km and has become one of the chief residential districts of the capital. Other sandar-type areas of heath and pinewoods are distributed in the northern part of the Kõrvemaa area and in the district of Alutaguse. Typical sandar areas are also to be found in the Valga Basin and the Väike-Emajõgi Vale, the Hargla Basin and the Vale of Võru, as well as in the Palumaa Area along the northern fringe of the Haanja Uplands. In general this type of landscape is unsuitable for cultivation, and therefore sparsely populated. Nevertheless, patches of fertile moraine surface are to be found here and there, with the result that the forested regions alternate with densely populated cultivated areas.

The West-Estonian limestone and moraine plains comprise the lower areas in the western part of the country, including the Western Archipelago. They have long been inundated and everywhere we meet typical surface forms produced by marine action. The numerous coastal barriers, which hinder the outflow of water, have given rise to large swamplands and saturated areas. On the islands and in the West-Estonian Lowlands we have limestone flats covered with dry meadows, which give place to hayfields and shrubby grassland in the moister areas and to populous farmland in the more fertile districts. All surfaces that are in the least tillable have been turned to account and converted into fields, which are surrounded for the most part by long walls of rough, loose stone. There are plentiful examples of *alvar*-type localities, but also of wooded meadows and deciduous forests, which on account of the calciferous surface are exceptionally rich in plant species and of great interest to the botanist.

The West-Estonian Lowlands and the large island of Saaremaa have been densely populated from early times, in striking contrast to the neighbouring island of Hiiumaa, which was referred to as uninhabited as late as the 13th century. There are few settlements of urban type in West Estonia, but the villages have to a certain extent preserved their patriarchal aspect up to the present day.

Plains of varved clays are of particularly frequent occurrence in the Pärnu Lowlands and in the river basin of the Kasari, but are also found in many other places in the West-Estonian Lowlands, the Western Archipelago and elsewhere. Well-cultivated fields mark the presence of fertile soils on varved-clay surfaces, which yield good crops when properly treated. The main problem here is that of drainage. Since this is easier in the immediate vicinity of rivers, the cultivated fields and the rural population are mainly concentrated along the river banks, while meadows and swamplands stretch away to the rear. The settlement of the Kasari and Pärnu basins did not begin until about the middle of the 13th century, considerably later than in the limestone areas.

Wooded lowlands are common in the Kõrvemaa area and in the district of Alutaguse in North Estonia, but they are also characteristic of large parts of West Estonia and of the basins of lakes Võrtsjärv and Peipsi. In these districts the land was inundated at the end of the Glacial Period by the water of the melting continental ice, and the sediments of glacial lakes are distributed widely over the whole area. Here and there occur glacial ridges or *åsar* and rounded hills, which give rise to numerous lakes. Only in a few places does the bedrock rise comparatively close to the surface, thus producing a somewhat different type of soil and vegetation. These localities are better supplied with arable land and are a little more densely populated. Of all the Estonian landscapes these areas are the richest in forests, some of which have retained their primeval character up to the present day, sheltering bears, large eagles, and a few other species, which if not absent from other parts of Estonia have at least become extremely rare. Fens and bog, among them some of the largest in Estonia, occupy a large proportion of these areas.

The wooded elevations of West Estonia can be regarded as a special type of landscape, differing in many respects from the uplands of the inner part of the country. They include the small moraine elevation in the middle of Köpu headland in Hiiumaa Is., the uplands of West Saaremaa and the small local elevation of Sõrve Peninsula, a few elevations round Tõstamaa and Varbla, and other similar areas. They are composed of fluvioglacial gravels and extremely stony moraines. In the majority of cases they are forest covered and are cultivated only in parts. These high areas are encircled by long lines of dunes, often bordered on the far side by swamps and marshes.

The coastal plains are typical of the central part of the North Coast, but also occur in the northern part of the West-Estonian Lowlands, in the neighbourhood of Pärnu and in many places on the islands. They are mostly extensive level tracts which have only recently risen above sea level (as a rule not until after the Littorina stage) as a result of the general uplift of the earth's surface. The bedrock outcrops in only a few places. The surface forms are predominantly of marine origin — terraces, coastal barriers and sand dunes. The cover consists for the most part of stony moraine and shingle with marine sands especially at the mouths of the rivers. Stretches of marshland occur here and there, interspersed with coastal lakes. The chief soils are of podsolic type, usually with sandy or extremely stony surfaces, and of low agricultural potential. The greater part of these areas is overgrown by coniferous forest. Where the surface is moister, wooded meadows also occur. Only a tiny percentage of the land is under tillage; but in the vicinity of Tallinn and Pärnu large numbers of market gardens are concentrated along the fine marine sands which constitute suitable areas for the cultivation of vegetables.

The oldest inhabited centres on the coast sprang up on the sites of former landing-places and fortified points. The agricultural settlement of the coastal strip began somewhat later than farther inland — not until the second half of the 13th century. Most of the settlements along the coast are fishing villages, which in the majority of cases are situated directly on the sea front. The North Coast, and also other parts of the coastal zone are dotted with holiday resorts, which are especially numerous in the vicinity of Tallinn, as well as in the north-eastern part of the republic.

A landscape of marshes and swamps is to be found in the lowest parts of the Võrtsjärv and Peipsi depressions, in the regions of Kõrvemaa and Alutaguse, and in the Pärnu and West Estonian Lowlands. In the region at the mouth of the river Emajõgi, as well as in the upper reaches of the same river, marshes and swamps abound, hemmed in by broad expanses of forest on the slightly higher ground. The countryside is almost unpopulated, except for a few fishing villages scattered along the banks of the lakes and rivers, and on some of the higher points in the marshland. The chief natural resource of these areas is peat, but cranberries *(Vaccinium oxycoccus)* are also of industrial importance. Only in quite recent times have certain sectors been reclaimed and taken into cultivation — the first *polder* areas in Estonia.

In modern times the utilization of the land resources of Estonia has been drastically modified with a view to adapting it to the needs of large-scale socialist production. As compared with the period before the Second World War the area of arable land has to some extent diminished; on the other hand the forested area has considerably increased. Many of the smaller and less accessible fields, as well as some areas of low fertility have been forested. Many natural meadows have also become overgrown with shrubs or trees, and have since been reclassified as woodland. On November 1st 1969, 0·3 per cent of Estonian territory was occupied by gardens, 18·2 per cent by fields, 8·3 per cent by hay-fields and 9·6 per cent by pastures, the total area of cultivable land being therefore 36·4 per cent. At the same time 38·0 per cent of the total surface was under forest and 3·6 per cent under shrubland. The rest of the territory is taken up by bogs and marshes, lakes and other inland waters, as well as the land occupied by settlements, communications, etc.

One of the most serious problems of land utilization in Estonia has been the pressing need for improvement. At present 809,600 hectares of land are drained, but only a part of this total consists of a thoroughly modern and efficient drainage system. In recent times an average of 40,000 additional hectares has been drained and brought under cultivation or forest annually.

A characteristic feature of the arable lands in Estonia is their disconnected and scattered character. Even after the considerable efforts made to create large fields on the collective and state farms the average cultivated unit does not exceed 2·8 hectares, and 53 per cent are less than one hectare in size. Thus, in addition to the immediate task of land improvement with the object of securing optimal growth conditions, there is the enormous subsidiary task of consolidating, wherever possible, the scattered units of arable land in such a way as to facilitate the introduction of large-scale mechanized cultivation.

Other changes in the landscape have been brought about by the growth of industry and the consequent regrouping of the population. Especially rapid has been the growth in urban population, which on January 15th 1970 accounted for 65·0 per cent of the total population of the country (as compared with 33·6 per cent in 1940). As a result of this influx of population into the towns, the absolute and — still more — the relative figures for the countryside have sharply diminished.

The above-mentioned changes have given rise to extensive modifications in the Estonian landscape. Large industrial enterprises, new towns and thousands of kilometres of highways and electric cable have sprung into existence. The former small farmsteads have been replaced by modern rural settlements, new production centres and large livestock and poultry stations built by the collective and state farms.

As a result of the rapid advance of science and technology man's impact on his environment has increased almost beyond measure. The problems of regional planning are now very much the order of the day, and are reflected in the new national project for regional development which is at present in process of elaboration. The aim of the investigations carried out in this field is to study and control changes effected in the landscape, to guide the exploitation of national resources along rational, complex lines, and to ensure that man's environmental conditions do not deteriorate as a result of increased production.

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III. CHANGES OWING TO HUMAN ACTIVITY IN THE HYDROSPHERE AND ATMOSPHERE

THE EQUILIBRIUM OF THE GEOGRAPHICAL ENVIRONMENT AND THE PRODUCTION

by

S. LÁNG

Production growing parallel with Man's activity transforming nature seems to exert an influence upon the equilibrium existing within the geographical environment. Changes in this equilibrium and even its possible breakdown greatly vary from place to place. At present in most cases this change is so slight that, compared to the processes of nature, it passes almost unobserved even by those with measuring apparatus. This is due to the ever changing atmosphere and hydrosphere which very rapidly counteract Man's activities by absorbing all excess materials and energy remaining after production. For instance the large quantity of CO_2 produced by cities and industrial agglomerations is in general carried off and diluted by air circulation. The water from rivers in flood withdraws to the streambed to be partly evaporated. On the other hand damage brought about by mankind is more noticeable and perhaps can never be healed as e.g. the damage caused by opencast mining, and the cutting of virgin forests on eroded soils, which regenerate only slowly.

1. Atmospheric change is brought about by energy production, which results in an accumulation of carbon dioxide and suspended particles in the atmosphere.

Over the last century, mining exploitation resulted in the pollution of the atmosphere with 80 thousand million tons of carbon derived from coal, 10 thousand million tons from lignite, 25 thousand million tons from oil, 3 to 5 thousand million tons from wood and natural gas plus 3 to 4 thousand million tons of ash, dust and soot. At present the carbon content of the atmosphere amounts to 700 thousand million tons which exceeds by 10 to 12 per cent that of the middle of the last century. The increase in the carbon content of the atmosphere is somewhat lower than expected and it is therefore estimated that 35×10^9 tons must have been mostly absorbed by the oceans in the form of carbon dioxide.

The newly irrigated agricultural territories should also be mentioned, which by accumulating organic vegetal materials, pollute the atmosphere with carbon dioxide. Thus a tropical area comprising one million sq.km of plant culture, if irrigated intensely and regularly, absorbs about 1×10^9 tons of carbon per year,' while carbon production of cultures in the temperate zones never exceeds 0.3×10^9 tons per annum.

However, as agricultural areas totalling 7 million sq.km in 1920 and 15 million sq.km in 1970 are expected to rise to around 20 million sq.km by the year 2000, 25 million sq.km by 2020 and 30 million sq.km by 2070, an ever increasing part of the carbon released into the atmosphere will come from agricultural production. In order to feed a world population of 5 thousand million people in 2000, 6 thousand million in 2020 and 7 thousand million in 2070, 2·5, 3·0 or $3 5 \times 10^9$ tons of food-stuffs respectively comprising a carbon content of 0·5, 0·6 and $0{\cdot}8 \times 10^9$ tons will be produced. However, the human population and domestic animals will convert these quantities through respiration into CO_2 which in turn will contribute to the pollution of the atmosphere.

Though the carbon content of the atmosphere derived from society's food production will be insignificant even after the world population doubles, some problems of acquiring will arise, such as e.g. to have irrigating water in quantity sufficient for the new growing areas of several million sq.km which can be rendered productive first of all in the subtropical regions, in the savannah and the temperate zones. Moreover, the problem of gaining well-cultivable areas for food production, on arable land, plantations, orchards, vineyards or gardens is extremely significant.

In the future if these territories are to recover investment costs, their production must be raised to optimal quality and quantities. This will also imply 50 per cent increase in the density of population in a hundred years time, which now attains 200 people per sq.km in agricultural territories.

Let us turn now to the danger of temperature increase which has become very serious in the recent years and has been discussed at several forums. This danger is closely tied to the increase of carbon dioxide content of the air together with the "greenhouse" effect which may raise world temperatures by 2 °C by the end of the century, and may cause a new problem to human society.

As regards this subject, let us give the following information. Up to the turn of the 2nd millenium the carbon content of the atmosphere is expected to increase by only 30 per cent, 200×10^9 tons over the present value and within one hundred years it will have doubled. In a view of the growing use of water and atomic energy, one may estimate that the carbon content may increase by about 700 to 800 thousand million tons.

Thus — taking into account marine absorption — the CO_2 content of the atmosphere will increase to 0·07—0·08 per cent and the oxygen content decrease to about 20·88—20·90 per cent.

As it is known, the mean annual temperature during the post-glacial climatic optimum in Western and Northern Europe was by 3 to 4 degrees higher than it is at present. Thus, in the extreme north, on the Taimyr peninsula there were at that time human dwellings which since ceased to exist. The taiga zone was also inhabited.

Although combustion is accompanied by soot, smoke and dust which constantly decrease the transparency of the atmosphere mainly in industrial regions, this is the component which disappears relatively most rapidly from the atmosphere thus leading to rapid regeneration. This is partly because the rising number of dust particles increases the number of condensation nuclei thus increasing rainfall.

Temporary accumulation of combustion products, including benzpyrene, in cities and in settlements in general is a danger to the human organism. However, it can be eliminated by conventional means such as the development of forest belts, parks, water jets and artificial ventillation at the foci of traffic.

In the geological past the CO_2 content of the atmosphere was not much higher than at present in view of the 10×10^{12} tons of coal deposited during the Upper Paleozoic. However, if this carbon dioxide content resulted from volcanic action, e.g. through large basalt traps and diabase sheets, higher carbon dioxide production has to be presumed than for instance during the Upper Paleozoic or at the present time, or during the next 50 to 100 years. The huge carbon dioxide quantities resulting from energy production may later be absorbed by the sea, without, however, being transformed into living organisms (planktonic materials, marine molluscs and corals).

2. By the way, the danger threatening the marine biosphere is much higher than might be expected from the general pollution of general geographic space, as biologists are warning the public. The pollution of the hydrosphere is much more dangerous than that of the atmosphere, as water possesses different properties and physical phases.

This is due to the fact that air belongs to the gaseous phase of a physical system for which one set of laws prevail. The small particles dispersed throughout its body are accessory materials (soot, smoke and radioactive dust for instance) and settle quickly through the condensation of water vapour. The process of purification is relatively rapid as air completely absorbs gases of the same density only. Gases of higher specific weight can be absorbed either by water or by the soil.

Unlike the atmosphere, the hydrosphere is predominantly composed of water which belongs to a physical system with different phases, just as water itself can take on the form of vapour or ice in the natural environment. In addition to these properties and multiple phases, water in its liquid state is an excellent solvent and emulsifying agent. One of its properties is that it circulates and is in perpetual motion during which it is in constant touch with earth's crust and the atmosphere. Consequently, the various harmful materials adhere to and dissolve in water in its liquid phase. And without any purification, this water flows into rivers, lakes and the sea. It is true that water — through self-purification — rids itself of refuse within a certain time through precipitation and deposition. However, very frequently, it is only by oxidation that it can cleanse itself thus reducing the level of oxygen for aquatic living organisms. This means the breakdown of the biological equilibrium in water and indirectly results in the diminishing of fish stocks.

Especially dangerous is oil pollution which is constantly increasing even in the oceans where according to M. Blumer it amounts to 3 million tons per year mainly through the washing of tankers. The stenochemical planktonic assemblages and a number of corals and other living organisms react strongly against it. The danger is being increased by the growing number of tanker accidents with the subsequent surface and subsurface pollution of the oceans. If coral atolls entirely cease to grow in the future, as a result the enrichment of the atmosphere in CO_2 is to be increasingly expected as the dissolving capacity of the hydrosphere becomes more restricted. However, as already stated, this is the lesser problem. Greater harm consists of the decline and killing of marine populations — the most important food resource of mankind. Moreover, the seas are being polluted especially where marine life is richest, namely along the shore-lines. These dangers can only be prevented by diminishing off-shore petroleum exploitation and tanker transportation. Wherever possible, oil should be replaced by natural gas, although no trend of this kind can be noticed in the world economy.

Industrial pollution of the rivers and lakes of the continents is also increasing. This includes phenol and other organic fertilizer compounds washed away in the course of soil erosion. But if fertilizer production data are compared with the quantities of water circulating over the surface of the continent- inclusive of rivers and lakes, these data would appear to be of little significance. However, the contrary is true as the excessive use of chemicals in restricted areas causes great damage, as was the case a few years ago in Lake Balaton when the fish population was decimated.

However, it is not only organic waste of industrial origin — phenol and agricultural nitrates and phosphates — that pollutes the surface and groundwater, but other wastes such as domestic sewage. Especially dangerous are the nitrates which are difficult to extract from water. Phosphates may be removed more easily.

Eutrophisation is also a phenomenon responsible for upsetting the chemical and biological equilibrium of terrestrial waters, leading to the excessive proliferation of algal flora and anaerobic conditions in deep-water zones already deprived of light. The same proliferation of algae may be brought about by the discharge of industrial hot water into reservoirs again resulting in the disturbance of the ecological equilibrium.

It is not an easy matter to ensure the production of industrial water in the quality and quantity needed especially in the branches of production needing much water without causing pollution. The consumption by water-intensive mining and industrial branches increases by leaps and bounds at the worldwide scale, and — after being used in most cases twice or even several times — is discharged into reservoirs with all the consequential pollution. This condition becomes especially serious in lakes where water exchange takes several years and where pollution thus builds up rapidly.

The demand for water increases at a rate far exceeding the size in mining and industrial production, for, owing both to new technologies and rising living standards, water has become one of the most essential prerequisites for modern life. This holds true of water demand in areas newly cultivated as extension is most feasible in regions of arid climate. In the United States where in 1920 water consumption was 6 per cent and in 1960 60 per cent of the surface fresh water reserves, all water reserves will be exhausted by 1980. According to M. I. Lvovitch (Sovietskaya Geografiya v Nashi Dni, 1962), industrial, domestic and irrigating water use will exceed 400 cu.km per annum in the year 2000. To cope with the resulting lack of water, recycling of supplies will increasingly have to be resorted to.

3. The most important man-made effects influencing the surface of the earth are due to mining and agricultural production.

Mining exploitation effects both the surface and subsurface layer of the crust. Mining does not yield any materials or energy resources capable of selfregeneration while the disturbed soil will only restore itself in a very long time if at all. Further mining areas are disfigured by spoil-tips on their surface and suffer from subsidence. Consequent upon these, the composition and structure of the earth's crust in mining regions is changed. Opencast mining leaves ugly scars which, together with the tailings provoke changes in the morphological features of the surface. The total volume of all mining waste produced in all regions of the Globe over the last 150 years must approximate 100 cu.km, while the total volume of open pits must be of the order of 40—50 cu.km.

The resculpturing of the earth's surface by mining exploitation may even be surpassed by the action of agriculture through the generation of soil erosion and the spread of gullies and ravines in areas temporarily without adequate vegetation protection mainly before sowing and after harvesting. As shown by the author's evaluations, the annual rate of soil erosion amounts to 4·5 to 5 cu.km through ablation and deflation. In non-tropical areas, in particular in the next century soils will be very thin as agricultural production will have encompassed practically the Globe leading to the soil degradation through the application of fertilizers and mechanical loosening. Examples for this can already be seen in some of the hilly regions of Hungary. Ravines and gullies increase at the expense of arable land at a rate of 50,000 hectares in the Soviet Union alone per year. Solely as a result of the maintenance of irrigation canals, 128 million cu.m of loam are annually lost through erosion.* At the global scale linear erosion losses may be estimated to be of the order of several cubic kilometres per year. Soil erosion is heavily increased by the breaking of pasture and grassland as well as by deforestation. It is interesting to note that forests, which covered 7 thousand million hectares at the middle of the last century, have now been reduced to an area less than 60 per cent of that figure. Even in the place of cleared tropical forests only bush-dotted savannahs can be found in the majority of instances.

One of the most considerable, and least harmful manifestations of soil erosion is that radioactive wastes introduced into the soil from atomic testing have been washed out and transported to flood-plain areas. The process leads to the enrichment of radioactive matter in the soils of irrigated flood-plain sectors.

4. Because of lack of space, the problem of the regeneration of the biological environment cannot be dealt with here.

CONCLUSION

According to the aforesaid regeneration varies across the surface of the Globe. Conditions are most simple in the atmosphere as solid particles held in suspension are subsequently deposited or released from the atmosphere during precipitation. Gases of high specific weight (e.g. the products of combustion) are mainly absorbed by the soil or by water. Such gases are associated with heavy motor traffic, the control of which is therefore highly desirable.

* Zabelin, I. M. (1970) Physical geography and the science of the future. *Mysl*, Moscow

The most crucial problem is the regeneration of the stagnant part of the hydrosphere, namely the seas and lakes, because the sea is always the base level of erosion. It is here that pollutants derived from the surface, the subsoil and even from the atmosphere, collect. The lakes of enclosed basins act as substitutes for the seas in this respect. Lakes of different size, whose catchment basins are at the same time areas of controlled discharge, represent accessory base levels of the first order.

The existence and very survival of mankind and human society depend mainly on the future degree of marine, lake and river pollution. However, areas on the land surface that act as temporary sites for the accumulation of pollutants are not to be neglected either. River valleys, basins and plains are such examples where for instance surplus fertilizer and manure that has accumulated over several centuries can do much harm. The polders of the Netherlands come to mind in this context.

The oceans comprise one of mankind's main food resources while the waters of the continents have been intensely polluted by crude oil and its by-products, phenol, leached sulphites and radioactive materials. The neutralization of the pollutants and the re-establishment of the former equilibrium are most difficult to achieve in the hydrosphere as it is the final and biggest pollution reservoir of them all.

Accelerated pollution nowadays is due to the increased exploitation of oil. The writer considers crude oil to be a more dangerous pollutant even than coal, for it envelopes the entire biosphere and finally infects the seas and other waters where possibilities for purification are scant. The continental shelves close to the major industrial regions, including the coastal zones where terrestrial life was once born, are most polluted. It is ironical that they should be the best suited areas for the intensive breeding of Algae as a food for Man in the future.

In the author's opinion, oil pollution can be checked despite its recent acceleration. International cooperation and coordination could achieve good results, by a conversion to energy resources which yield neither pollutants, nor superflous waste, but which do require higher investments. For instance, the wind especially along coast-lines and in the mountains, and tidal energy whose exploitation has already produced results beyond the experimental stage could be utilized. Marine wave energy has not been exploited either. There are still many unexploited resources in the realm of water power, despite the fact that serious progress has already been achieved. Moreover, not even solar energy has been put to use except in agriculture, although there are over 3,000 hours of sunshine in the deserts offering opportunities for exploitation. As for atomic energy, this entails other possibilities for pollution.

If mankind made suitable use of the energy resources still unexploited that do not pollute, although the cost might be higher, the danger threatening mankind would diminish and survival of civilisation would be ensured.

THE WATER RESOURCES OF EUROPE AND WAYS TO COMBAT THEIR FUTURE POLLUTION

by

M. I. LVOVICH and G. M. CHERNOGAEVA

In the recent decade the problem of water supply for people and economics has become extremely urgent and acute. Many scientists are of the opinion that the development of mankind will be limited by available water resources.

Some authors paint a dark picture of the inevitable depletion of traditional water sources, such as surface water and groundwater, and suggest a search for other water supply sources.

A scientific approach to the solution of this problem leads to the conclusion that water-resource depletion is not inevitable. Water resources that can serve people are being continuously renewed within the hydrological cycle. But to accomplish this, some of the principles of water-resource conservation need to be changed. It is particularly essential to cease using rivers and reservoirs for the discharge of waste from urban industrial and agricultural water supplies. It is the pollution of rivers and reservoirs that is the main cause of water-resource depletion. To clarify this point the water resources of Europe must be assessed, their present state and feature must be established as the basis for long-term forecasts and the wise use and conservation of water resources must be determined. In the Institute of Geography of the Academy of Sciences of the USSR such studies have been carried out for the whole earth, and for the USSR and for some of its characteristic natural and economic regions.

THE WATER-RESOURCE BALANCE OF EUROPE

Hydrologically Europe is the most studied part of the world. Suffice it to say that in Europe observations are being carried out at about six thousand river gauge stations. During the last 70 to 80 years, many works have been dedicated to the study of river run-off, precipitation and evaporation in selected parts of Europe and for the whole of the Continent (Zaikov, 1938; Lvovich, 1964; Grimm, 1968 and others).

At present a more accurate assessment of the water resources of Europe is more dependent on the establishment of a new method of studying water resources having a lithogenous link in the hydrological water cycle (groundwaters, soil moisture) than on an increase in the number of key hydrological stations (Lvovich, 1959; Lvovich et al., 1963).

The method is based on the following set of equations:

$$P = U + S + E; \qquad R = U + S; \qquad W = P - S = U + E;$$

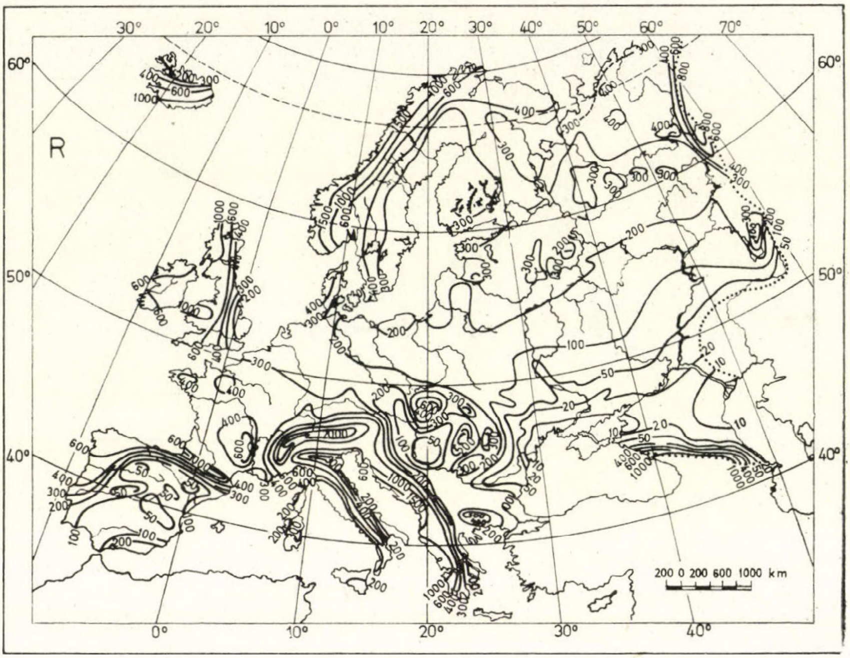


Fig. 1. Map of the total river run-off (R) of Europe, mm

$$K_u = \frac{U}{W};$$

where P is precipitation, R is total river run-off, U is groundwater discharge into rivers, S is surface (flood) run-off, E is evaporation, W is the total moisture of an area, K_u is the coefficient of groundwater discharge into streams.

To solve this set of equations, a method of separating total river run-off into the groundwater and surface water components is used. Such a method appeared long ago (Genits, 1903; Glushkov, 1961) and was first widely used for the USSR (Lvovich, 1938), then for the world (Lvovich 1945) again for the USSR (Lvovich, Bass, Green and others, 1961; Lvovich, and Dreier, 1964; The water resources of the USSR, 1967; The water balance of the USSR, 1969). The method was also used abroad (Natermann, 1951, Monografia geogr. RPR, 1960; Geography of Bulgaria, 1966; Rakichevich, 1968).

For reasons of space, we shall not review the literature on the water balance of Europe and its selected river basins studied on the basis of the old water balance equation ($P = R + E$), for example by A. Penck (1896), E. V. Oppokov (1904), H. Keller (1906), E. M. Oldekop (1911), and others.

At present studies on the water balance of the continents of the world are being carried out using this method.

Generalized maps of the major elements of the water balance of Europe compiled with the help of data for 370 rivers are given in Figures 1, 2, 3 (Chernogaeva, 1968, 1969a, 1969b).

The first map showing total river run-off in Europe was compiled by B. D. Zaikov (1938). It was made more accurate by Lvovich in the process of compiling maps of world river run-off during the following years in 1945, 1960 and 1964.

Maps of the elements of the water balance were used to assess approximately the water resources of all European countries. Generalized data on the water balance and water resources of Europe for four major regions are given in Table I.

TABLE I

The water balance and water resources of Europe

Water-balance elements (water sources)	Regions*				
	Northern	Western and Central	Southern	Eastern	The whole of Europe
1	2	3	4	5	6
			mm		
Precipitation, P	826	1,014	773	638	729
Total river run-off, R	614	552	333	204	319
Groundwater discharge into rivers, U	206	216	125	64	110
Surface run-off into rivers, S	408	336	208	140	209
Total moisture content of an area, W	418	768	565	498	531
Evaporation, E	212	462	440	434	410
Coefficient of groundwater discharge into rivers	0·49	0·28	0·22	0·13	0·27
Per cent of groundwater feeding the rivers	33	39	38	31	34
			km^3		
Precipitation	1,040	1,227	1,170	3,737	7,175
Total river run-off	770	668	505	1,195	3,140
Groundwater discharge into rivers	260	261	190	372	1,080
Surface run-off into rivers	510	407	315	823	2,060
Total moisture content of an area	530	930	855	2,914	5,115
			m^3 a year per capita		
Total river run-off	36,860	3,400	4,040	4,630	5,249
Groundwater discharge into rivers	12,380	1,330	1,550	1,440	1,809
Surface run-off	24,480	2,070	2,490	3,190	3,440

* Northern region: Denmark, Iceland, Norway, Sweden, Finland;
Western and Central regions: Austria, Belgium, Great Britain, Luxemburg, The Netherlands, France, FRG, Switzerland;
Southern region: Albania, Greece, Spain, Italy, Portugal, Yugoslavia;
Eastern region: Bulgaria, Hungary, GDR, Poland, Czechoslovakia, the European area of the USSR

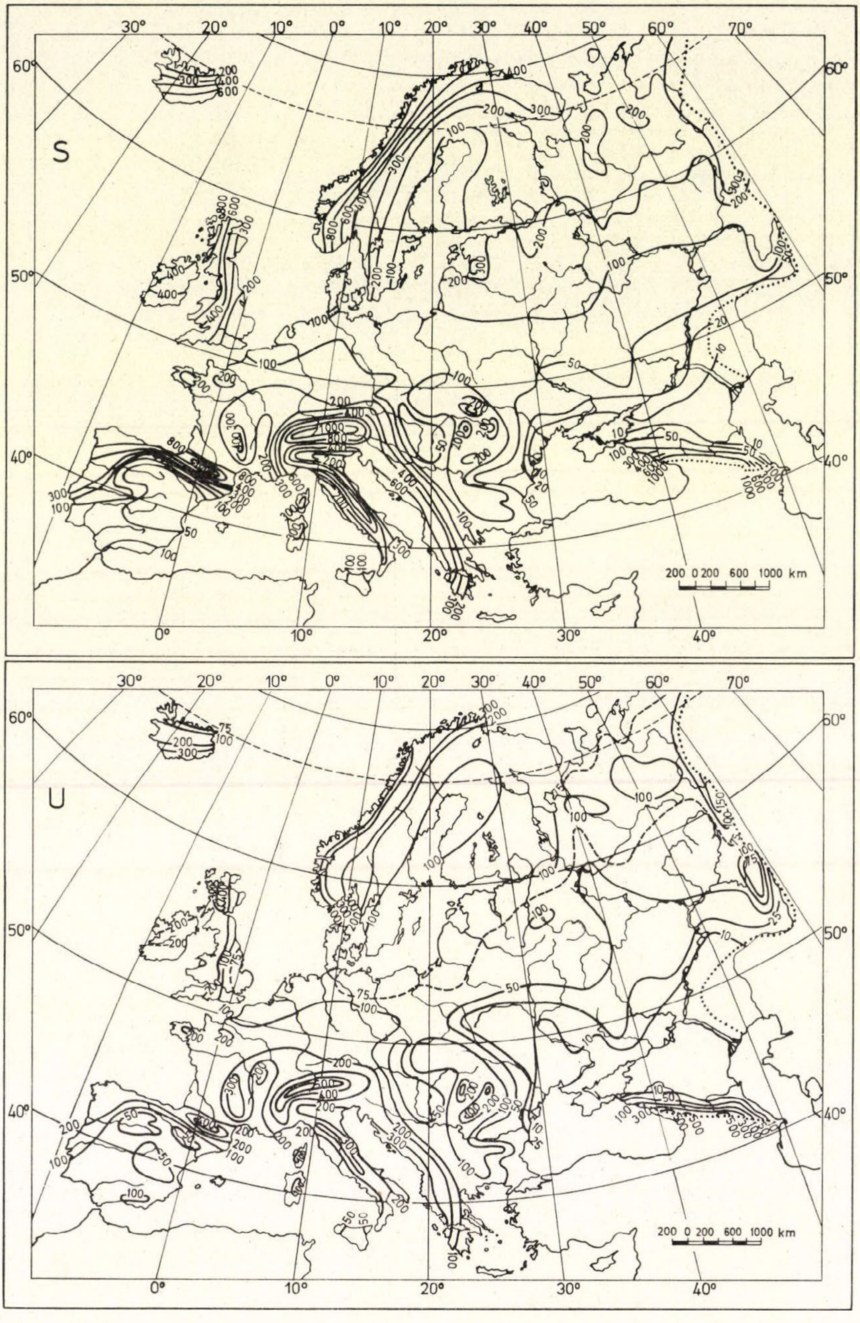


Fig. 2. Maps of the surface (S) and groundwater (U) run-off of Europe, mm

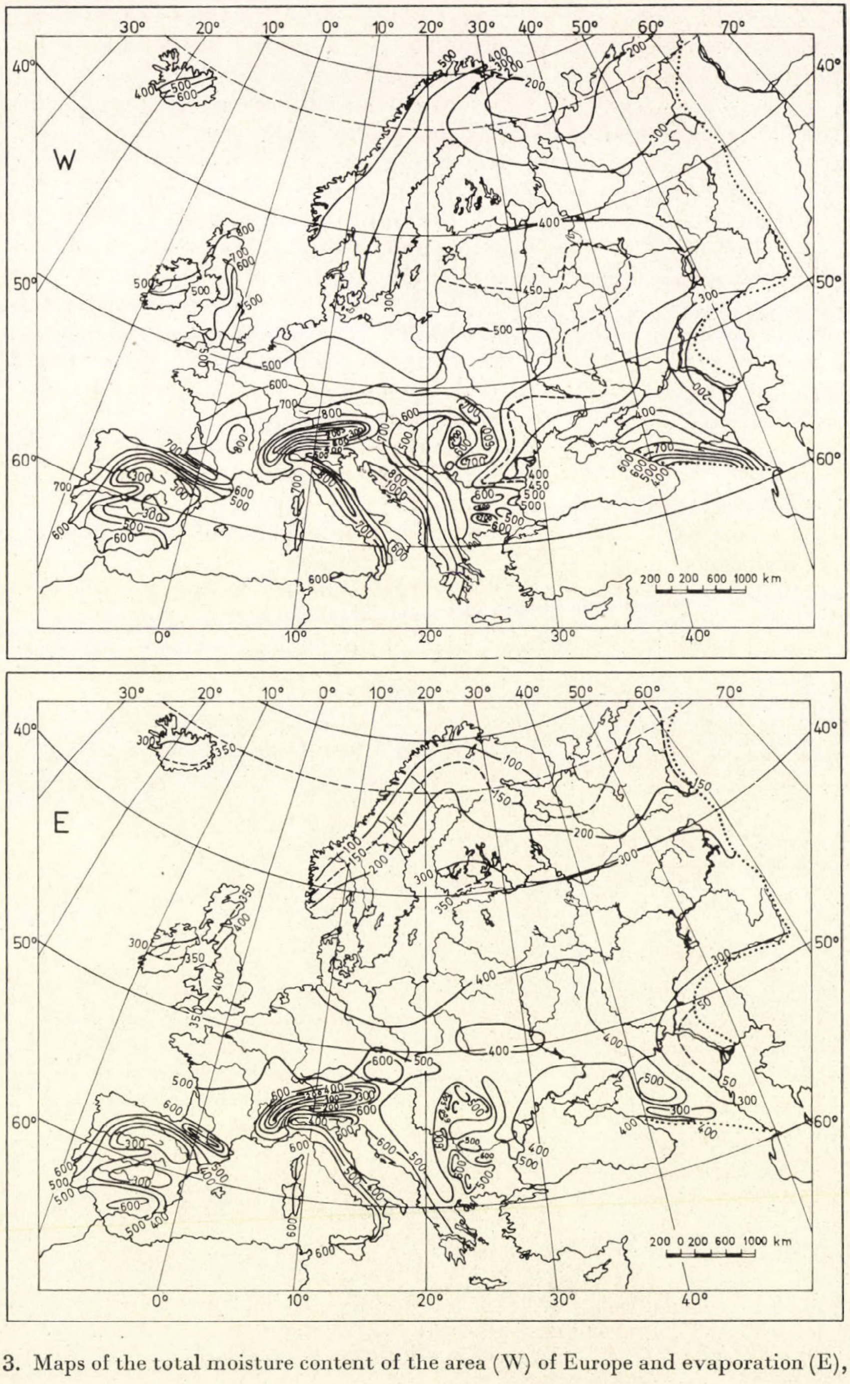


Fig. 3. Maps of the total moisture content of the area (W) of Europe and evaporation (E), mm

Groundwater discharge into rivers is the most valuable water source. It is extremely stable in time and provides the cleanest water discharge into rivers. In this respect groundwater run-off has an advantage over unstable surface water which causes floods and carries into rivers different pollutants from urban and agricultural areas (fertilizers, pesticides and weed killers). At the same time groundwater discharge into rivers characterizes groundwater storage in the zone of active water exchange within the limits of their natural drainage basins. In general, the total moisture of an area is characterized by soil moisture storage which is an essential component of soil fertility.

To obtain a complete picture of the amount of stable run-off, river run-off regulated by lakes and reservoirs should be added to groundwater discharge into rivers. In Europe this comprises about 250—300 cu.km per year. From this it follows that total stable run-off increases to 1,250—1,300 cu.km, while flood run-off decreases to 1,650—1,700 cu.km. This amount characterizes available potential water resources after regulation.

It is appropriate to mention here that unlike some other natural resources, water resources lend themselves to expanded renewal. The latter means an increase in the valuable resource provided by stable run-off which is easy of access as far as its use is concerned, at the expense of less valuable flood water which is difficult to use.

The comparison between the water resources of Europe and those of the world (Table II) indicates that with an equal amount of precipitation tota. river run-off in Europe is almost 20 per cent higher than that of the worldl

TABLE II

The water balance of Europe compared with that of the whole world (mm)

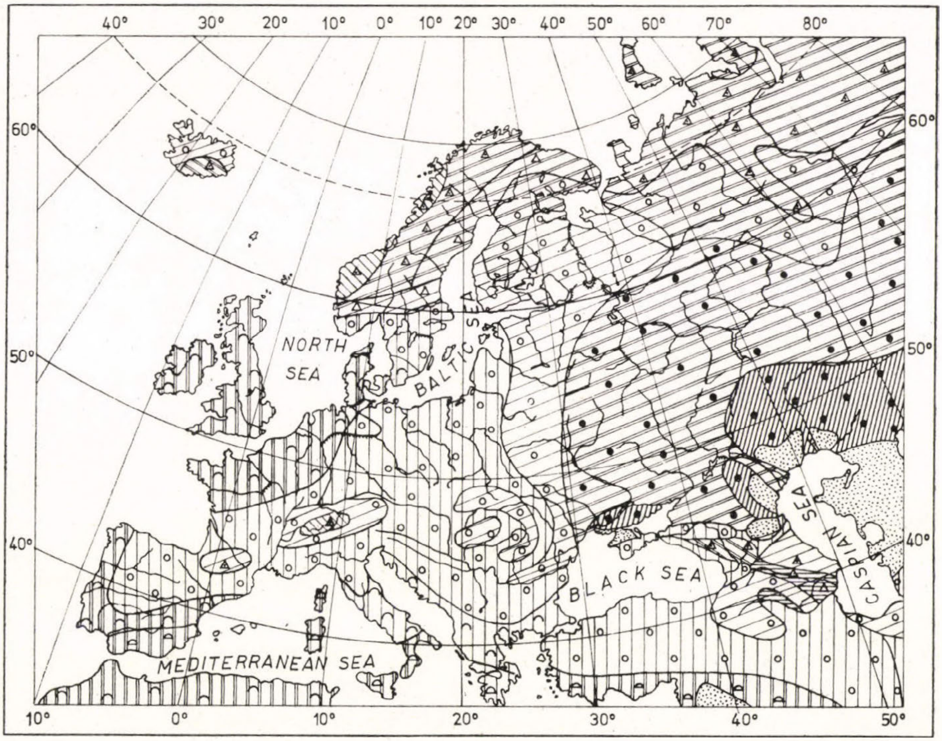
	P	*R*	*U*	*S*	*W*	*E*
Total land area of the world	730	260	81	179	551	470
Europe	729	319	110	209	531	410

The more favourable conditions of European water resources are especially emphasized by the fact that groundwater run-off is 36 per cent higher than the world average.

Stable run-off regulated by lakes and reservoirs together with run-off of ground origin makes up about 100 mm for the whole of the world and 125—130 mm for Europe i.e. is 25—30 per cent higher in the latter area.

GEOGRAPHICAL REGULARITIES IN WATER BALANCE AND RIVER REGIMES

Geographical regularities in the water balance of Europe were first studied by A. Penck in the latter part of the last century and then by H. Keller (1906) on the basis of total river run-off and the flood relationships that they estaba



b

Distribution of run-off by season / Sources of recharge			Spring			Summer			Winter	
			almost exclusively	over-whelmingly	predominant	almost exclusively	over-whelmingly	predominant	over-whelmingly	predominant
			P	Py	py	E	Ey	ey	Hy	hy
snow	almost exclusively	S								
	overwhelmingly	Sx								
	predominant	sx								
rain-water	overwhelmingly	Rx								
	predominant	rx								
glacier	overwhelmingly	Gx								
	predominant	gx								
ground-water	predominant	ux								

Fig. 4a, b. Map of the water-regime types of European rivers lished. Following on their theory, G. Brenken (1960) derived a water balance equation for the different climatic types of Europe and for selected regions of other parts of the world (cited after R. Keller, 1965). In 1945 M. I. Lvovich published a map of the types of water regime of the rivers of the world.

A supplemented and more accurate variant of the map for Europe is given in Fig. 4 (1964). The typology of river regimes is based on 2 features. There are the sources feeding rivers (subsurface, rain, snow, and high-mountain glaciers) and the distribution of run-off according to calendar season. To quantify the prevalence of different types of source and seasonal run-off three gradations are taken: around 80 per cent, between 50 and 80 per cent, and around 50 per cent.

Out of the 38 river regime types in the world, revealed by this method, 16 types are found in Europe and are marked in the legend of the map. The major water regimes of the rivers of Eastern Europe are presented chiefly by the spring snow feeding types *S—P*, *Sx—Py* and *sx—py*. Only in the north are found rivers of the *Sx—Ey* type due to summer snow melting. There is even an *Sx—E* type in the southern island of Novaya Zemlya, where the warm season is limited to the summer months. Different water regime variants prevail with rainfall feeding being prevalent east of 25° longitude as well as in the Balkan Peninsula; feeding from springs (*rx—py*) in Central Europe, in the Baltic Republics and in the north of the Balkan Peninsula; and by winter run-off (*Rx—hy*, *rx—hy*, *Rx—Hy*) in the north of Western Europe and in the Mediterranean.

A transitional type of regime with a slight prevalence of spring snow run-off (*Sx—py*) is characteristic of the western part of the EAU,* the eastern part of Poland, the Carpathians, the Balkans as well as the Alpine foothills and Pyrenees. Rivers fed from mountain glaciers (*gx—Ey*) are widespread in the Caucasus, Alps, Scandinavian mountains and in the southern half of Iceland

TABLE III

Zonal regularities in the water balance of the European part of the USSR (mm)

Zones and subzones (indices according to Fig. 5)	Characteristic data						
	P	*R*	*U*	*S*	*W*	*E*	*K*
Ia Tundra and forest-tundra	665	300	75	225	410	335	0·19
IIa_1 Northern taiga	700	350	125	225	475	350	0·26
IIa_2 Middle taiga	750	290	95	195	555	460	0·17
IIIa Mixed forest	715	170	60	110	605	545	0·10
IVa Forest-steppe	650	100	30	70	580	550	0·06
Va Steppe	495	40	9	31	464	455	0·02

* EAU — European area of the USSR.

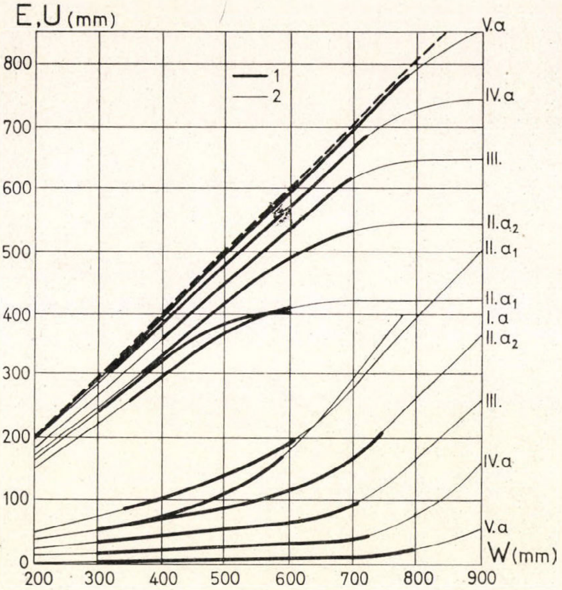


Fig. 5. Zonal regularities in the water-balance structure of the European part of the USSR

1. — Empirical curves; — 2. Theoretical curves
I.a — Tundra and Forest-tundra; II.a_1 — Northern taiga; II.a_2 — Middle taiga; III—Mixed forest; IV.a—Forest steppe; V.a — Steppe
E — Evaporation; U — Groundwater; W — Moisture

while type $g—E$ is characteristic of the Arctic islands. In Southern Zavolzhye the $(S—p)$ regime is to be found which is characteristic of the dry steppe of the temperate belt with pronounced continentality. Although summer precipitation prevails here, it is absorbed by the soil and evaporated, and a short run-off occurs during the spring melt.

The differentiated method of studying the water balance on the basis of the above mentioned set of equations enabled one to establish zonal regularities in the structure of the water balance of an area. With this aim in view structural water balance curves are constructed which show the relationship between groundwater discharge into rivers, evaporation and the total moisture content of an area. The curves $E = f(W)$, at the limit, approach potential evaporation (evaporation $= E_{\text{max}}$); the curves $u = f(W)$, at the limit (when $E = E_{\text{max}}$) map at 45°, which corresponds to groundwater discharge into rivers at the rate $K_u = I$.

Zonal regularities in the water balance are pronounced in the continental part of Europe, namely the European area of the USSR (Table III, Fig. 5) (M. I. Lvovich, 1962, 1969).

In northern areas the structure of the water balance is least favourable in the tundra especially if permafrost is present. Then the coefficient of groundwater discharge into rivers decreases to 0·04—0·06 and almost the whole of river run-off occurs at the expense of the surface (flood) run-off. Run-off structure is extremely favourable in the taiga. However, with due consideration to climatic heat resources the water balance of the forest-steppe zone is recognized as the most perfect. The steppe zone is better endowed temperature-wise, but here soil moisture is insufficient.

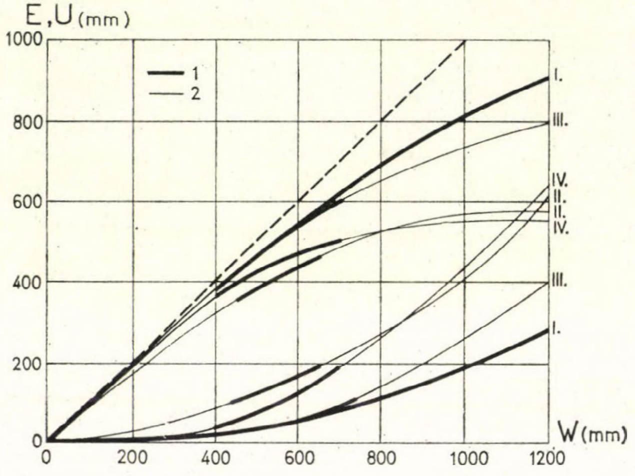


Fig. 6. Examples of the water-balance structure of some regions in Western and Central Europe

1. — Empirical curves; 2. — Theoretical curves
I. — Mediterranean region II. — Western European broad-leaved wet forest; III. — Lowlands of Romania and Bulgaria; IV. — Lowlands of GDR and Poland
E — Evaporation; U — Groundwater; W — Moisture

Analogous types of water balance are established for some of the natural regions that extend beyond the USSR (Fig. 6, G. M. Chernogaeva). The water balance structure of Bulgaria generally coincides with that of the mixed forest and forest-steppe of the EAU but with a higher moisture supply. The water balance structure of the Carpathian rivers of Rumania approaches the conditions of the southern and middle taiga of the EAU. The same can generally be said about the broad-leaved forest zone of Western Europe. As far as the water balance structure of the Mediterranean is concerned it is similar to the forest-steppe of the EAU but with double of the total moisture content.

The feeding of a river is dependent upon the hydrogeological structure of its basin. However, this conclusion refers chiefly to extreme hydrogeological conditions, for example, to large expanses of karst, especially those with no sedimentary cover, or to basins comprised of highly permeable volcanic tuff. But in most cases, when river basins are composed of sedimentary rock, the effect of hydrogeological structure is less, and the feeding of rivers from groundwater is governed by the regularities of geographical zonality.

TRANSFORMATION OF THE WATER BALANCE AND RIVER RUN-OFF AS A RESULT OF ECONOMIC ACTIVITY

The area where the water balance has been unaffected by man's activity has decreased. Over large areas in Europe river run-off has been regulated to some extent, for power generation and for improving navigation. Suffice it to say that the usable storage of reservoirs built on the largest rivers of Eastern Europe, namely, the Volga (with the Kama) and the Dnieper, is over 110 cu.km, making it possible to regulate almost half of the flood run-off of these rivers and to double or treble run-off during the low water stage. Losses through evaporation from reservoirs increased water expenditure by about 10 cu.km a year in the basins of the Volga, Don and Dnieper rivers. In Bulgaria no less than one third of surface flood run-off is regulated by reservoirs. In general in Europe more than 1,500 reservoirs have been built with usable storage capacity of not less than 250—300 cu.km. Certainly, it is an important factor of the transformation of the hydrological regime and partly of the water balance.

Another factor is intensive exploitation of groundwater resulting in the infiltration of sea water into underground horizons. The artificial recharge of groundwater horizons is a promising method of combating this phenomenon. This method undoubtedly has a future since it allows the regulating of flood run-off with the least expenditure of land which is inevitable in the building of surface reservoirs. Artificial water storage underground makes it possible to prevent pollution. In transforming the water balance of an area regulation bringing about agricultural, forest and hydrological amelioration is of great importance.

Thus, studies of the effect of measures aimed at increasing crop production on the water balance and river run-off in the southern half of European Russia show that autumn ploughing almost unused before the development of mechanized Kolkhoz agriculture, is an important factor influencing the local water balance. The local effect of autumn ploughing on surface run-off from fields, as established by field studies in different areas of the USSR, is shown in Fig. 7. It is seen from the figure that autumn ploughing decreases surface run-off by between one and a half to two times in the forest zone, by two to three times in the forest-steppe zone and by four to six times on the steppe. From this it follows that the agronomical influence on the water balance is also governed by geographical regularities.

The magnitude of the transformation of river run-off in the southern half of the EAU (Table IV) has been established on the basis of experimental studies with the help of a special method which makes it possible to precalculate the change in water balance and river run-off (Lvovich, 1963, The water balance of the USSR, 1969).

Soil moisture resources accordingly increase and soil fertility rises since it is dependent on the water component as well as on water loss through evaporation.

Analogous conclusions concerning the transformation of the run-off of the rivers in Western Poland have been drawn by Polish scientists (Dubrowin and Roginski, 1954). Thus, according to their calculations in the early 1950s

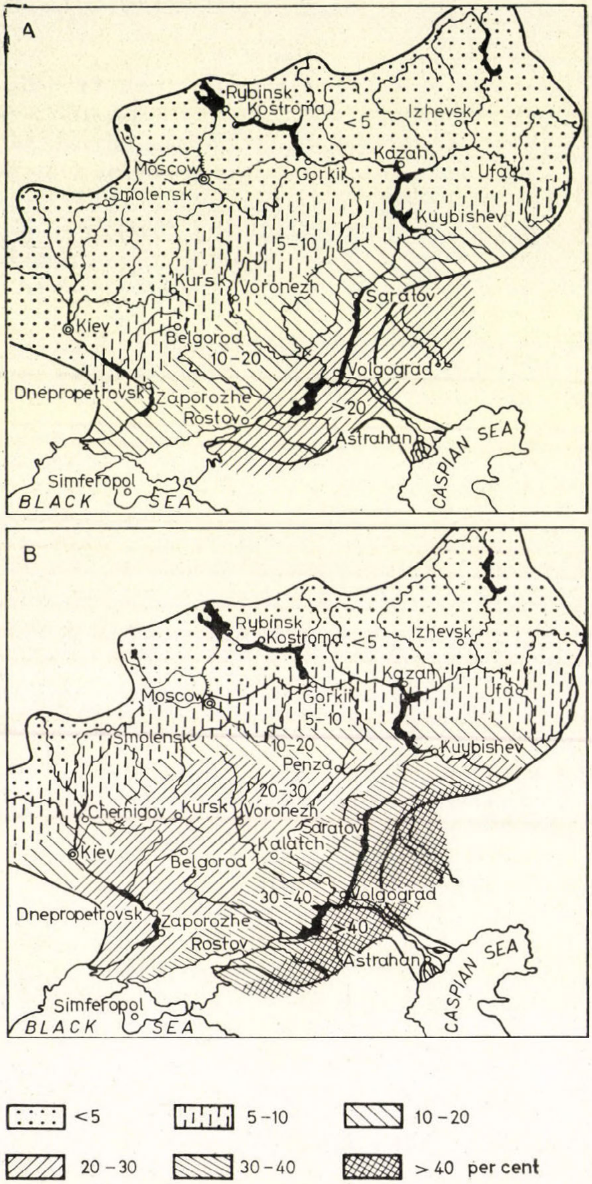


Fig. 7. River run-off reduction in the southern half of the European part of the Soviet Union due to the increase in agricultural production

A — In Ihe early 1960s; B — Forecast for 1975—1980

TABLE IV

Run-off changes of major rivers in European southern USSR

River	The total river run-off, km³		Decrease in run-off			
	from the whole basin	from the area most used for agriculture	up to the late 1960's	km³	per cent of total run-off	per cent of run-off from the area most used for agriculture
Dnieper	50	25	1·8	5	10	20
Don	30	30	4·2	9	12	30
Volga	250	80	6·0	20	8	25
Total	330	135	12·0	34	av. 10	av. 25

the run-off of the Notets compared with the period 1883—1892 decreased by 38 per cent as a result of agriculture. H. Kalweit (1953) estimates the increase in evaporation from the surface of the Saale River through the growing of post-harvest crops and improved agrotechnics as 17 mm a year with a corresponding decrease of 15 per cent in river run-off. The same author considers that for identical reasons the run-off of the Lippe River decreased by 48 mm between 1919—1921 and the late 1940s, i.e. almost 10 per cent of the natural run-off of the river.

The data mentioned for different periods refer to the same climatic conditions, so the difference in the amount of run-off is caused only by man-induced changes in the water balance.

An assessment of the effect of agriculture on the water balance and river run-off is of great importance since the given source of water expenditure is not usually taken into consideration in the management of the water balance. However, it makes up a marked part of the balance. To solve the problem purposeful experimental studies of the water balance of arable lands must be carried out under different conditions of soil treatment and different yields.

WAYS TO COMBAT WATER POLLUTION

European countries fall into the category of having high levels of urbanization and industrial concentration. It should be added that in European towns as well as in the rural areas high norms of per capita water use are often applied.

Water withdrawal from rivers, reservoirs and underground sources amounts to about 125 cu.km a year for all kinds of municipal, energy and industrial water supply. 40 cu.km of the amount is withdrawal and the remainder of the order of 85 cu.km is discharged into rivers, reservoirs and the sea in the form of waste water. Much of the waste water is treated before discharge but a large amount is still discharged without treatment. If we assume that about 10 cu.km are diverted into the sea, annually about 75 cu.km enter rivers, lakes and reservoirs. It is supposed that as a result of self-purification processes the waste waters are rendered harmless. Indeed, the process brings about positive results if a small amount of waste water enters rivers and reservoirs but with any large increase the self-purification ability drops and the waste water is not rendered completely harmless.

Norms of dilution to render waste water harmless differ according to local conditions but for treated waste water a tenfold dilution is usually used. With due regard to the fact that some kinds of waste water, for example warm water from electric stations, require only a three-fold dilution, we may assume the dilution norm to be an average eight to one.

Then the 75 cu.km of discharged waste water may be estimated to pollute to some extent no less than 600 cu.km of river water. There is no reason to consider this amount an overestimate. It comprises 46 to 48 per cent of the stable run-off and almost 20 per cent of the total run-off of the rivers of Europe.

Taking into consideration the unevenness in the distribution of population and economy, the fact that in some regions of Europe a much greater amount of water is spent on waste water dilution compared with the whole of Europe, becomes evident. This means that in such regions water pollution already exceeds the permissible limits and that waste water is not rendered completely harmless. There has been much written concerning the pollution of many European rivers and reservoirs and there is no need to repeat it.

The artificial cleaning of waste water is a method of combating this problem. Of course it slows down the qualitative depletion of water resources but does not solve the problem completely. A major cause lies in the fact that even perfect means of treatment do not render waste water completely harmless: 5—15 per cent of the most persistent pollutants remain.

With the growth of population and economy the amount of waste water increases so rapidly that even with total purification the remaining pollution does significant harm to rivers and reservoirs. For this reason the purification of waste water followed by discharge into rivers and reservoirs cannot solve the problem by itself. It is not sufficiently effective and it is expensive.

With the aim of achieving a constructive solution a series of measures should be taken based on waste water reuse. It is advisable to use a considerable part of urban, rural and some types of industrial waste water for field irrigation. This measure is of importance since soil is a very favourable medium for rendering waste water harmless especially if used with small irrigation norms. In Europe the area of arable land is as extensive as 310 million ha out of which 16 million are at present irrigated. In future at least 40 million ha will be irrigated, for which not less than 100 cu.km of water will be required annually. As a rule it will be advisable to use waste water.

One thousand cubic metres of waste water from municipalities contain 20—100 kg of nitrogen, 40—50 kg of potassium and 18—20 kg of phosphorus. With the future waste water norm for irrigation reduced to 2,500—2,700 cu.m/ha (against the present value of 3,700—4,000 cu.m/ha) the soil would be fertilized with nutrients equal to 40—60 tons of manure or to 1·5—2 tons of mineral fertilizer. The application of such an amount of fertilizer provides high crop yields. Thus for example, in arable fields near Moscow irrigated with waste water grass yields are 3—5 times greater than those without irrigation. Due to a high effectiveness of irrigation with waste water investment in irrigation systems is recovered within 3 to 5 years. At the same time waste water is rendered completely harmless.

The health, agronomical, technical and economic sides of the problem of irrigation with waste water have been tested in many experiments carried out on tens of thousands of ha in different countries.*

Thus, waste water which is harmful when discharged into rivers and reservoirs becomes useful. With the application of waste water to irrigation we succeed in rendering waste water harmless and at the same time derive benefit from its use.

Another measure is the conversion of industrial and heat power generation to closed recirculating water-supply systems. Water treatment should be sufficient to allow the reuse of waste water by a given establishment or by some other production activity which does not require water of high quality. To be successful, this method of rendering waste waters harmless must form an integral part of production technology.

An essential measure is the conservation of water by all possible means, so as to decrease its expenditure per unit of production until "dry" technologies are established wherever possible.

Finally, it is very important to combat the pollution of rain and snow-melt water through the use of herbicides, pesticides and other toxic chemicals. It is quite evident that with this aim in view urban areas must be kept clean and, in addition, settling basins must be built to collect the most polluted run-off especially at the beginning of snowstorms and during snow melt. Concerning the washing out of toxic chemicals from fields, a most efficient means is to eliminate surface run-off. Such a way is justified, and in a series of cases it has been shown to be quite feasible as discussed in the section "Transformation of water balance . . .". The other side of the problem is that where it is absolutely necessary to apply toxic chemicals, minimum amounts should always be used.

Approximate calculations indicate that with such an approach to the purification of waste water, that is purification by using water resources in the process of production itself, Europe is well enough endowed to meet the water requirements of her people and of her economy in the long-term future.

To realize such an optimistic conclusion, the implementation of the abovementioned measures must be commenced so as to bring a complete cessation of waste water discharge into rivers, reservoirs and seas during the next one and a half to two decades.

* USSR health rules prohibit the use of unworked vegetables grown in fields irrigated with waste water.

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MAN'S INFLUENCE ON THE HYDROLOGICAL CYCLE OF THE FEDERAL REPUBLIC OF GERMANY

by

R. KELLER

For more than 200 years, the negative influence of man on the quality of water has been described in the literature; the negative influence is due to urbanisation and industrialisation. Today, water pollution is the most important problem of water management in industrial and urban regions.

A large number of studies have discussed the problem of water quality. On the other hand, there are only a few studies on the influence of man on water quantity.

Therefore, it is intended to discuss some ideas relating to this problem. In 1951, the author published the first estimation of the water balance of the Federal Republic of Germany for the period 1891—1930. In 1970, he published a new calculation for the period 1931—1960. In both cases, the calculation of the water-balance was carried out according to the same procedure:

(1) determination of mean precipitation. For the area of the Federal Republic of Germany a mean annual value for precipitation of 825 mm is obtained from the precipitation maps of the period 1931—1960 (1891—1930 : 800 mm),

(2) the calculation of transpiration and the determination of evapotranspiration. The method of calculation has been enlarged upon elsewhere (Keller, 1951, 1961–65, 1971b),

(3) total run-off is obtained by differencing recorded precipitation and calculated evapotranspiration. On the basis of run-off quantities recorded at water gauges, run-off may be divided into surface- and groundwater run-off,

(4) water demand for industrial and domestic purposes may be determined with reasonable accuracy from the annual hydrological statistics of the Federal Republic (Clodius, 1962, Keller, 1952, 1971a).

THE DETERMINATION OF EVAPORATION

The basis of the method is the measurement of transpiration, where the mass of transpiring material is also given. The author has assembled in a diagram the transpiration values for 13 characteristic natural plant formations, consisting of 62 different plants.

An increase in absolute water-consumption with an increasing production of fresh matter is not to be denied. If it is assumed that the relationship between plant-mass and transpiration, outlined here, is also applicable to cultivated plants, then the result obtained is that a rye crop of 2,000 kg/ha grain yield requires more water than a wheat crop with the same yield. Here, I want to dispense with a special interpretation and analysis of this diagram, and stress only the following essential facts.

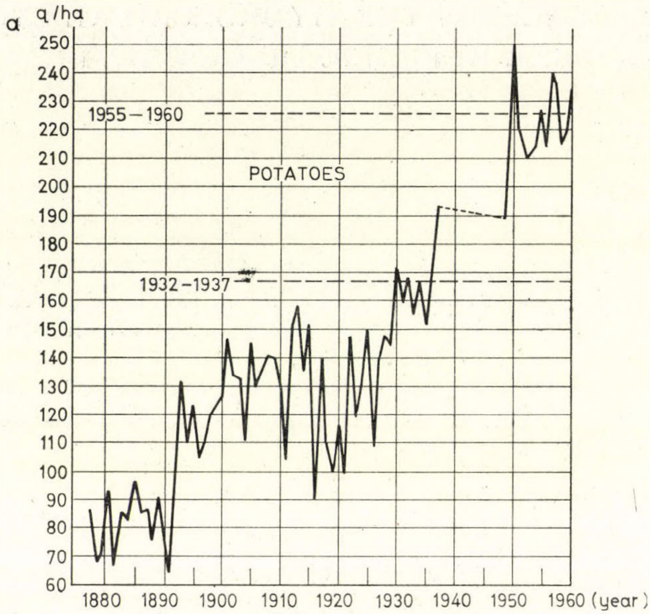


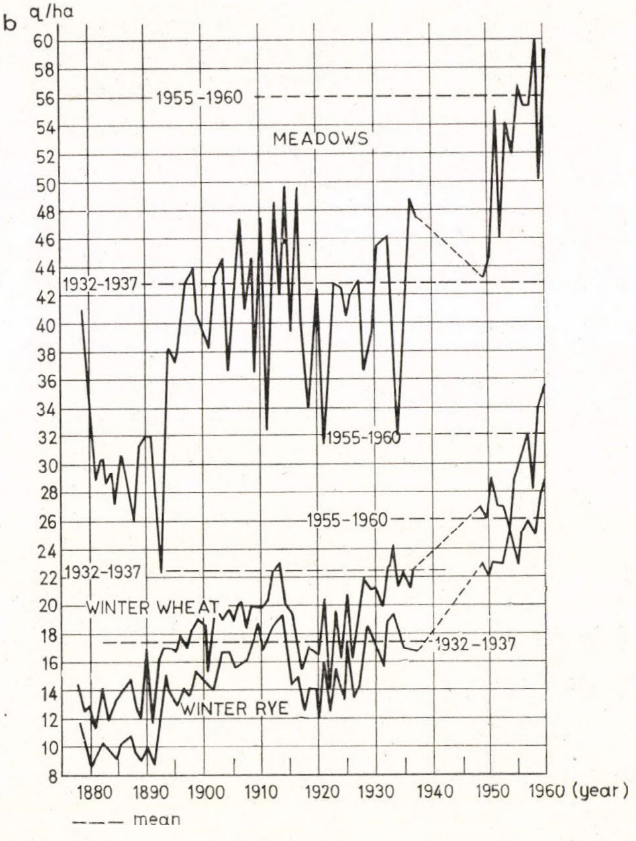
Fig. 1a, b. Yields in the "Deutsches Reich" respectively in the Federal Republic of Germany from 1880—1960

TABLE I

Cultivation, yields and water consumption in the agricultural area of the FRG (10-year means for the period from 1951 to 1960. Calculation according to R. Keller, 1951)*
Agricultural area: 142,570 sq.km

Crop	Mean yield (q/ha)	Cultivated area, as per cent of the total productive agricultural area	Water requirements	Product of columns 3 and 4
1	2	3	4	5
Wheat				
(a) straw	42·33	8·47	398·4	3·374
(b) grain	29·79			
Rye				
(a) straw	45·75	9·98	412·0	4·113
(b) grain	25·28			
Other cereals				
(a) straw**	35·50	15·16	336·2	5·097
(b) grain	26·41			
Sugar-beet	349·28	1·80	424·4	764
Fodder-beet	456·24	3·00	316·1	948
Potatoes	219·73	7·83	222·6	1·743
Clover	60·53	6·85	445·0	3·048
Grassland	53·90	46·91	398·0	18·670
		100·00		37·753

* Source: Statistical Yearbook for the FRG 1951—60.
** The mean yields for oats straw amount to 36·83 q/ha and for other kinds of straw 34·60 q/ha. Thus, a mean value of 35·5 q/ha for "other cereals" results.



According to this, the possibility exists that with increasing crop yields, water requirements also increase. The marked increase in crop yields in the German Reich, and, in post-war years, in the Federal Republic of Germany is illustrated in the Figures 1a and b. The crop yields for the most important cultivated plants are published in the Statistical Yearbook of the Federal Republic of Germany.

The increase in crop yield is achieved by improving the ear-straw ratio. Therefore, the referring lines for the water consumption of the field crops in the years from 1950—1960 differ from a former period (Fig. 2).

The water requirements shown in column 4 of the Table I, were obtained by means of the logarithmic formula for transpiration values.

The mean transpiration value for the agricultural area of the Federal Republic of Germany, for the period 1951—1960 accordingly amounts to 378 mm per annum.

Moreover, it is assumed that the relationships outlined above are also applicable to woodland, which yields a mean transpiration of 355 mm. Thus,

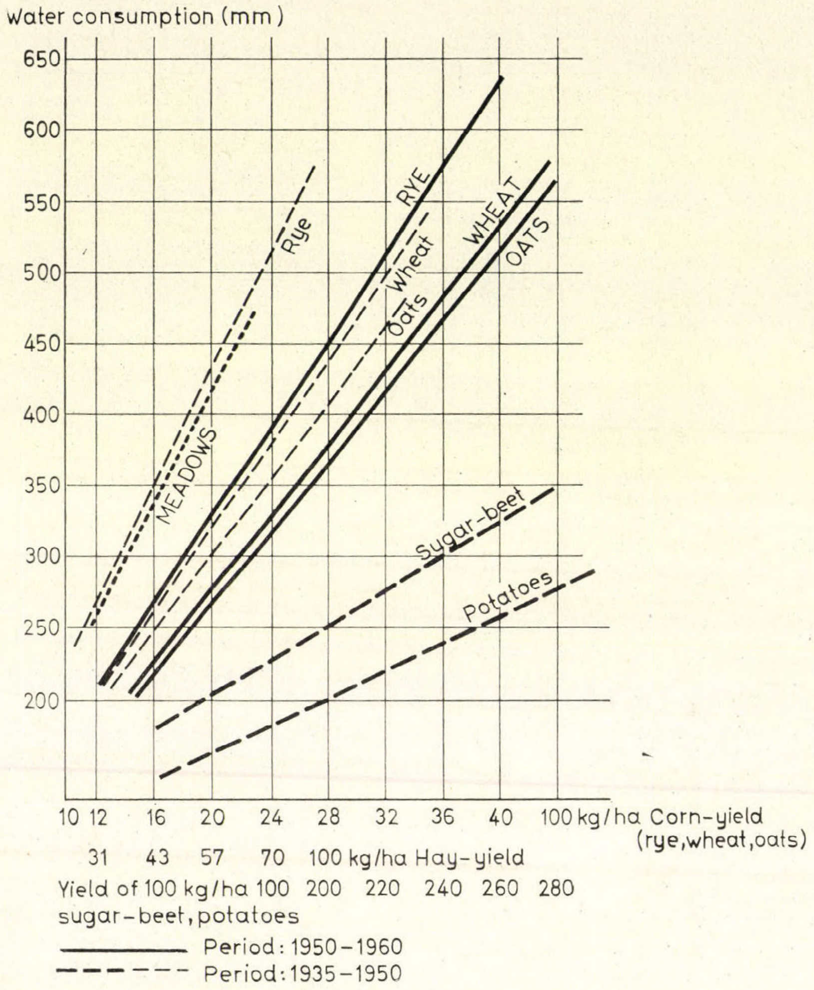


Fig. 2. Water consumption of different yields (corn, hay, bulbed plants) in the FRG

the mean transpiration amounts to 370 mm (including the agriculture area with 57·47 per cent and the area of woodland with 28·2 per cent of the total area of the Federal Republic). 85·67 per cent of the total area of the Federal Republic of Germany has been covered in this calculation. Water surfaces include 1·65 per cent of the total area and they are considered separately in the hydrological cycle, as in their case potential evaporation is effective. As the mean evaporation from open water surfaces, being a continuous process, cannot be directly measured by instrumental means, the methods of Haude and Penman were employed, giving a potential evaporation of 620 mm; this includes 10 mm for the evaporation from open water surfaces.

EVAPORATION AND GROUNDWATER RUN-OFF

An average run-off of 296 mm for the period 1931—1960 was recorded on the area of the Federal Republic. With an annual precipitation of 825 mm of the same interval of time a surplus of 529 mm remains, distributed amongst transpiration, evaporation and groundwater run-off. In the preceding section 370 mm was calculated for transpiration, to which may be added about 4 mm to allow for evaporation of water used for industrial, business and domestic purposes, 1 mm for irrigated surfaces, and 10 mm from open water surfaces. Thus, a total of 385 mm is obtained for the evapotranspiration sector. Accordingly, only the balance between 385 and 529 mm, namely 144 mm, remains for evaporation and run-off replenishment of groundwater.

Lysimeter observations on bare soil, and studies on interception provide the criteria for the estimation of evaporation. If an interception of 200 mm is assumed for woodland, then, since the proportion of woodland to the total area of the Federal Republic is 28·2 per cent, an evaporation of 100 mm would appear reasonable. Indeed, this value was used in the author's calculation of the hydrological cycle in 1950, as no other experience on interception in woodland was available, then or in 1970. This value was obtained by investigations in special small river systems, in which the method of calculation was compared with the balance obtained from precipitation minus run-off.

Assuming an evaporation of 100 mm, the total actual evaporation amounts to 485 mm, and 44 mm still remain for groundwater percolation. It is perfectly possible that certain variations may occur in the distribution of the remaining 144 mm between evaporation and groundwater. This distribution could be determined least exactly than the other data of the hydrological cycle which have been recorded, or calculated according to clear-cut objective procedures. However, the over-all picture of the hydrological balance would not alter significantly, if evaporation were to increase or decrease by 10 to 20 mm and groundwater percolation to alter correspondingly.

THE OLD AND THE NEW SCHEMES OF THE HYDROLOGICAL CYCLE

On the basis of the available data, industrial water statistics, crop yield statistics, run-off and precipitation observations, the plan under discussion is readily calculated. The method of calculation fixes the actual values of all data, although it would be desirable to have a more scientific basis for the climatic function $L(t)$ in the logarithmic equation for transpiration.

The new scheme (Figs 3, 4) has significant advantages over that of 1950. It is the first scheme of the hydrological cycle which is based on corresponding periods for almost all elements.

Various differences in the figures between the old and new schemes should be mentioned: The new value for evapotranspiration is 485 mm, 81 mm higher than the old figure. The increase in evapotranspiration was due entirely to the higher crop yields for the period 1951 to 1960. Whilst evapotrans-

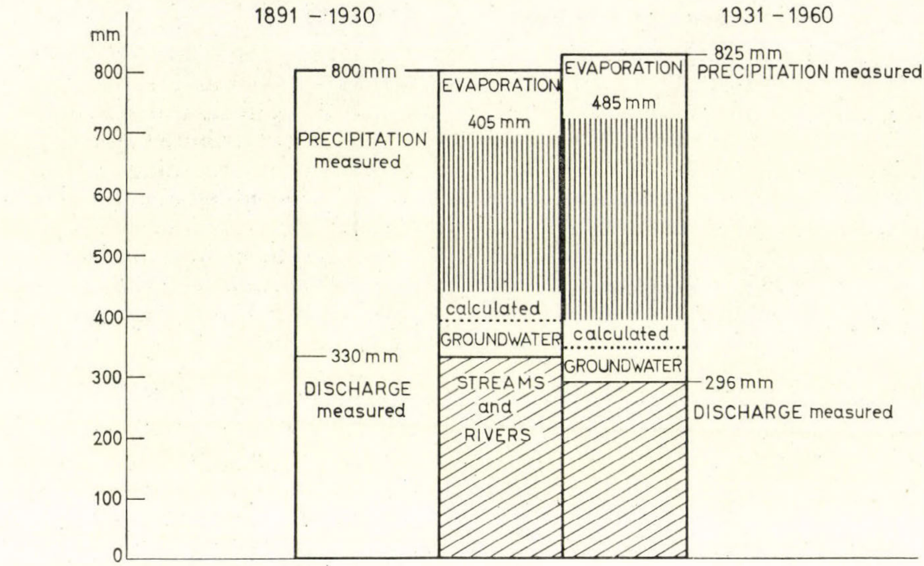


Fig. 3. The water balance in the FRG (1891—1960)

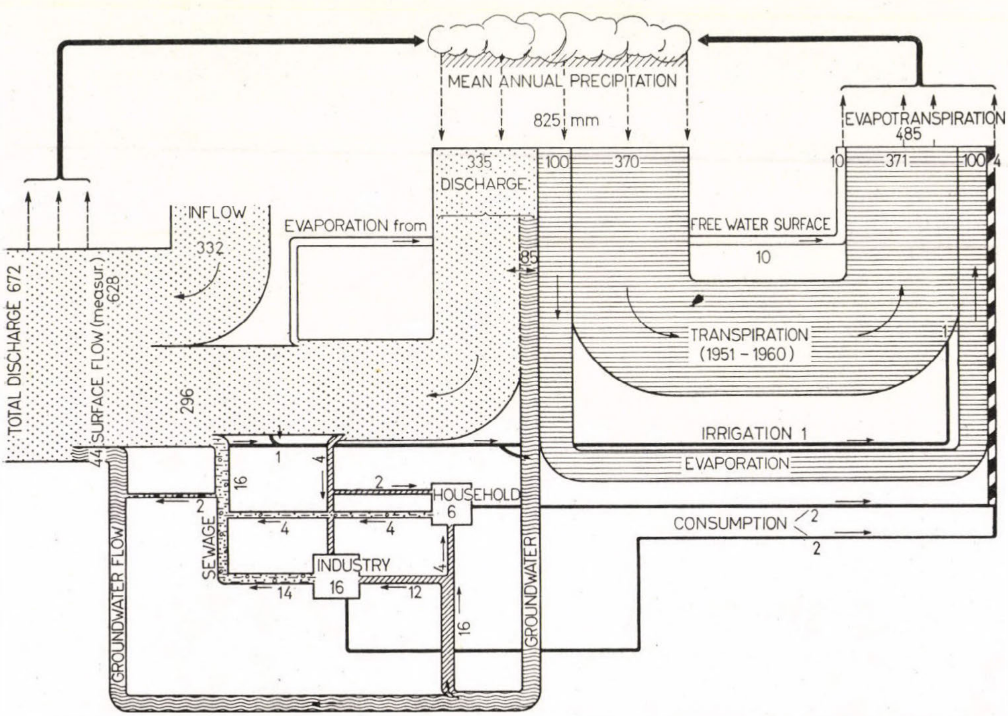


Fig. 4. Plan of the water balance in the FRG

piration has increased, run-off has decreased. In the old scheme run-off amounted to 396 mm, 66 mm of which went to the groundwater and 330 mm to streams and rivers (recorded at gauging stations). For the period 1931 to 1960 total run-off amounted to only 340 mm, that is 56 mm less than in the old scheme. 296 mm of this was via the rivers (i.e. run-off recorded at water gauges) and 44 mm went to the groundwater.

The decrease in run-off is all the more astonishing, as the precipitation level of 825 mm for the period 1931 to 1960 was 25 mm higher than that for 1881 to 1930. This increase in precipitation has — always provided that the basis for observations and the assumed marginal conditions are correct — benefited evaporation rather than run-off. This is a somewhat unexpected result.

Surely, one can state that the 25 mm increase in precipitation lies within the limits of measurement error. On the other hand, it can be asserted that the trend is for an increase rather than for a decrease in precipitation. The decrease in run-off is quite unequivocal in regard to the trend towards an increase in precipitation between 1931 and 1960.

Should these findings prove to be reliable, a matter of serious concern has been brought to light. It means that — besides the already known negative influence exercised by human beings on water quality — their influence on the hydrological cycle is stronger than previously thought.

It has been known for a long time that the spatial and temporal distribution of run-off in rivers and in groundwater may be changed by man, but it is only recent knowledge that the extent of evaporation can so much be influenced by man. Two points of view have been considered in recent time:

(1) the influence of industry and settlement on the atmosphere by heating the atmosphere over cities and industrial areas with consequential variations in the energy budget,

(2) the increasing production from arable land.

In general, evaporation can be influenced by a change in land use.

Certain changes are also to be found in the data concerning groundwater: 66 mm (old) and 44 mm (new). It has already been mentioned that there is some uncertainty in the distribution of the remaining 144 mm between evaporation and groundwater percolation; 44 mm for groundwater results simply from allocating 100 mm to evaporation. On the other hand, this value is credible. There is certainly groundwater over extensive regions of the Federal Republic of Germany. Groundwater runs off, but it does not flow seawards over extensive areas; rather, the greatest part reappears at some point as surface water in springs, streams, or in the water supplies of settlements and industry, and is discharged to sea throug streams and rivers. The 44 mm for groundwater, which appears in the scheme, is not discharged in the sea via rivers within the boundaries of the Federal Republic of Germany. For example, on the Lower Rhine, groundwater moves towards the Meuse, where water level is 7—8 m lower than the nearby Rhine. In the regions of glacial drift in Northern Germany there is also the possibility of groundwater flowing into neighbouring areas, or via the coast-line out to sea. Expressed in terms of the total area of the Federal Republic groundwater run-off remains low.

It was not intended to present here just the waterbalance of the Federal

Republic of Germany but also to indicate the influence of man on the hydrological cycle, with respect to water quality, quantity and distribution. These are matters of such an importance that, in the years to come, hydrological and ecological research work will become a central focus in the study of "Man and Environment".

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ECONOMIC ACTIVITIES INFLUENCING THE FLUVIAL REGIME OF THE PAZARDJIK AND PLOVDIV PLAINS

by

L. ZIAPKOV

Since September 9th, 1944, Bulgaria's general development has greatly increased the exploitation of water resources in all national economic fields. Enterprises were set up almost everywhere to improve agriculture and sylviculture which greatly modified both the water regime and water budget. Studying these modifications was of great importance for the subsequent rational exploitation of water resources and the conservation of Nature.

The fluvial regime of the Pazardjik and Plovdiv plains has been greatly modified. The water of the Maritsa river was first used for irrigation (possibly during the 14th century). Between 1868 and 1872 the "Pacha-ark" and "Eni-ark" irrigation canals were built near Pazardjik and Plovdiv. During capitalist times, because of Bulgaria's backward economy, her water resources, although insufficient, were exclusively used for irrigation. It is in this field that the first irrigation cooperatives were set up named "Hydraulic Trade-Unions". Their total irrigated area amounted in that period to some 2,500 hectars, that is 70 per cent of the country's total irrigated area. The Hydraulic Trade Unions exploited the waters of the Maritsa, Topolnitsa, Tchepinska, Vatcha, Tchepelarska and Striama rivers (Fig. 1) on the basis of the gravity principle. On account of the backwardness and limitations of this method its effect on the natural water regime was almost nil.

Political changes have considerably contributed to hydrological developments. The exploitation of the waters of the Maritsa river and its tributaries was several times doubled for both irrigation and industry. Irrigation systems were developed at Aleko-Pazardjik (in 1961–1962), Varvara (1962), Pechtera (1960–1961), Karabunar (1961–1962), Topolnitsa-Parvomai (1950–1953) between 1959 and 1962 for the irrigation of 22,700 hectares of land (Fig. 2). In the Vatcha, Tchepinska and Stara reka river basins the Hydroelectric Plant of Batak (1951–1956) was built, while the Topolnitsa (having a storage capacity of over 140 million cu.m) and the Piasatchnik reservoirs (over 60 million cu.m) were constructed. On the lower reaches of the small rivulets of the Strednagora and the Western Rhodopes over 300 small dams and reservoirs irrigating more than 3,000 hectares of land were constructed.

The irrigating system is mainly fed by the Topolnitsa dam and reservoirs (averaging 190 million cu.m per year), the Batak dam (123 million cu.m per year), the Maritsa river, the catchment schemes near Belovo railway station (averaging 20 million cu.m per year) and the village of Zlokutche (averaging 30 million cu.m per year), the Tchepinska river (averaging 21 million cu.m per year), the Luda Iana river (averaging 4·5 million cu.m per year), the Vatcha river (averaging 57 million cu.m per year), the Striama river (averaging 52·5

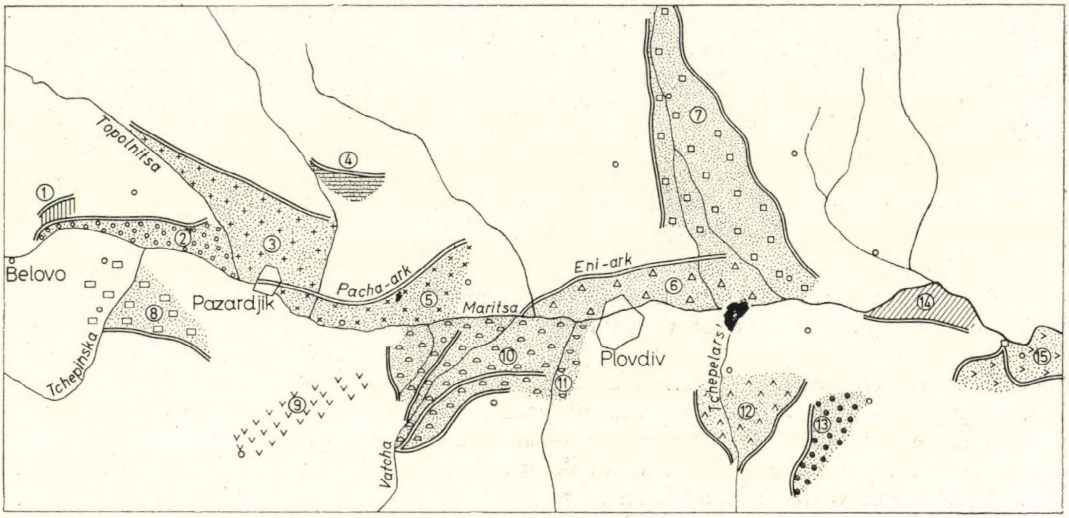

Fig. 1. Map of irrigated areas of the Pazardjik and Plovdiv plains (before September 9th 1944)

1 — Chamkar; 2 — Straza; 3 — Topolnitsa; 4 — Progres; 5 — Trakia; 6— Maritsa; 7 — Striama; 8 — Eli dere; 9 — Stara reka; 10 — Rhodopes; 11 — Ferdinand; 12 — Assenova krepost; 13 — 40 Izvora; 14 — Popovitsa; 15 — Iagoda

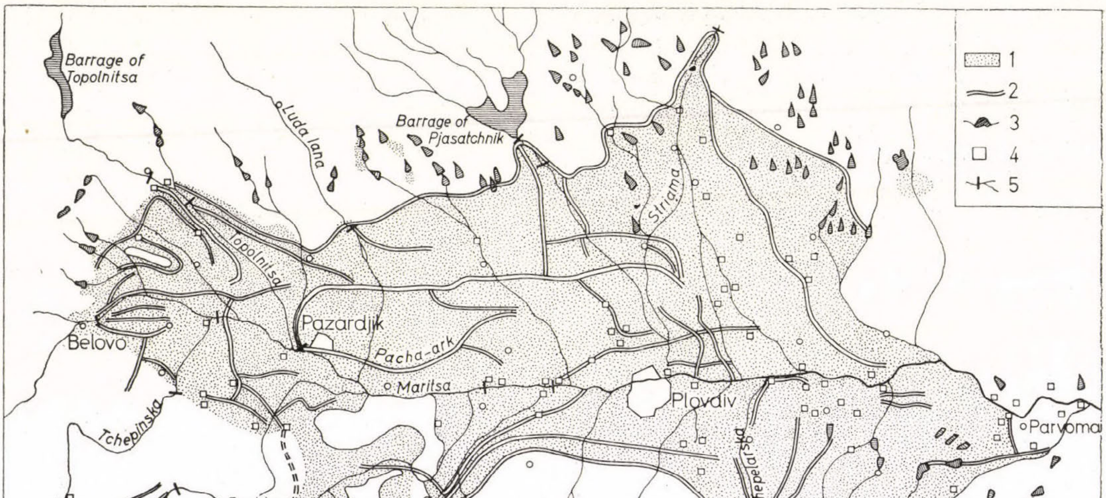

Fig. 2. Map of irrigated areas of the Pazardjik and Plovdiv plains (recently)

1 — Irrigated areas; 2 — Irrigation channel; 3 — Barrage; 4 — Water-pump; 5 — Dam

million cu.m per year) and the Pjasatchnik dam and reservoir (averaging 63·3 million cu.m per year).

These systems mostly irrigate ricefields, vegetable gardens cereal- and maize-fields, vineyards, tobacco and lucerne fields, orchards, and sunflower fields. The irrigation season usually starts between the 15th and/or 20th of April and ends between the 15th and 20th of September, the high season being between the middle of June and the end of August. The irrigation norms which vary from crop to crop are between 20 and 1,000 cu.m. The norms are highest for rice — between 2,400 and 3,600 cu.m — and for vegetables between 400 and 1,000 cu.m per 100 sq.m.

Much lower water quantities are used by industry with the exception of the Plovdiv industrial enterprises (cannery factories, sugar-refineries, lead and zinc works, paper mills, brewing works); the factories at Pazardjik (cannery works, vine factories, a rubber plant; accumulator works), the plants at Assenovgrade (cannery), the works at Kritchim (canneries, paper mills and cellulose works) and the cannery at Parvomai.

Further changes in hydrography on account of follow-up schemes included the construction of irrigation systems with a total length of over 750 km (draining channels, dams and micro-dams).

Examples of the changes in river water distribution are: the Batak hydroelectric power plant conveying dammed water to the upper reaches of the rivers Pevinska, Stara reka, Tchepinska and Dospatska, and the Batak reservoir, and the Pechtera and Aleko hydroelectric plants whose discharge is diverted to the irrigation systems of Pazardjik and Plovdiv. The waters of the Topolnitsa dam are diverted to the East of the Striama river via the Lessitchevo, Striama and Guelemenovsky channels. It is via these same channels that the waters of the Maritsa and the Luda Iana rivers, the Pjasatchnik and Batak reservoirs, as well as the Striama river are discharged. Almost all the waters of the Vatcha river are diverted through the Kritchim channels to the valley of the Tchepelarska river after Assenovgrade.

CHANGES IN THE SEASONAL REGIME OF RIVERS

In terms of the total annual discharge, the normal summer flow in June-July-August of the Maritsa river is 2·0 to 3·5 per cent near Belovo railway station, 1·8 to 2·0 per cent near Plovdiv and 1·4 to 2·1 per cent near Parvomai. Since the building of the irrigation systems the summer discharge between Belovo railway station and Parvomai has remained unchanged despite the fact that the gradient is now higher than under the earlier regime. However, summer discharge near Plovdiv is 0·10 to 0·75 per cent and near Parvomai 0·08 to 1·40 per cent less than that of the normal regime.

The insufficient discharge of the Maritsa river at drought peaks is supplemented by water recovered from the irrigation systems. The summer discharge of the Maritsa river decreases near Plovdiv and, particularly near Parvomai on account of falls in direct catchment on the one hand, and the lower water level of its tributaries on the other. Between June 15 and August 31, the following rivers run dry: the Topolnitsa from Lessitchevo village upstream, the Tchepinska above Varvara village, the Luda Iana above Tchernogorovo village, the Tanragka below Parvenezt village, the Vatcha from its confluence with the Kritchim and Pjasatchnik rivulets above the dam of the same name, the Tchepelarska above the town of Assenovgrade, and the Striama above Tchernozem village.

QUALITATIVE CHANGES IN RIVER WATERS

Before 1959 the water of the Maritsa was polluted only from Pazardjik, Plovdiv and Parvomai downstream, and its waste content only slightly exceeded the acceptable norms. Later on, especially after 1963–1964, water quality has become much worse in almost all rivers. The Maritsa river is now polluted over its entire length, from Kostenezt to Parvomai, the Topolnitsa river from MOK Medete downstream, the Tchepinska river from Velingrade downstream, the Luda Iana river below the irrigation plant near Dolno Levski village and the Tchepelarska river from its confluence with river Iogovska downstream. Mean pollution content was above the admissible norms, during the period of 1960–1966, in the following rivers: in the Maritsa river near Parvomai where it amounted 91 mg/l, in the Topolnitsa (268·6 mg/l), in the Luda Iana near the village of Sbor (712·6 mg/l, and in the Tchepelarska river at the village of Batchkovo (637·1 mg/l). The rivers Pjasatchnik, Striama, Tamracka, Vatcha and the Tchindardere are less polluted.

CHANGES IN THE GROUNDWATER REGIME

Groundwater occurs at depths of 0·5—1·5 m and 2·0—4·5 m in the low and high river terraces respectively. The groundwater reaches its highest annual level during the months between December and February, and lowest level between September and November. Since the building of the irrigation systems the ground-water table and the level of stagnant water in low-lying areas tend to rise during the months of June and July.

The artificial changes in hydrography, the distribution of river waters, and the seasonal regimes of the rivers and groundwater exert an influence upon the water budget of the region. The changes of water budget include the ratio between the "debits" (river discharge and evaporation) and "receipts" (precipitation), in addition to the ratios between surface and subsurface run-off and total evaporation.

Total evaporation increases at low water stage and decreases the amount of surface run-off on account of a greater soil humidity. Tendencies favourably influencing changes in the water budget are due to Bulgaria's national economy and socialist principles of exploitation.

The results obtained so far, are temporary in character as only isolated aspects of the problem have been faced up. An integral solution requires the clarification of the following problems:

— An assessment of the influence of economic activities upon the annual and seasonal discharge of the rivers.

— The determination of the quantitative characteristics of the factors ensuring water equilibrium under the most typical agricultural conditions.

— The determination of the effect of irrigation on water circulation.

It is unquestionable that the integral solution of the problem will contribute to the efficient exploitation of water resources as well as to the preservation of the natural environment of the Pazardjik and Plovdiv plains.

GEOGRAPHICAL ASPECTS OF WATER CONSERVATION IN ARID MOUNTAIN COUNTRIES

by

L. A. VALESSYAN

Water utilization holds a prominent place in the whole complex of problems concerning the rational use and preservation of the natural resources of the Earth. It is common knowledge that the problem of providing populated areas, agriculture and industry with fresh water is becoming increasingly difficult with population growth and the development of productive forces.

At present, representatives of many branches of science throughout the world are concerned with the imminent danger of "water hunger". It is becoming obvious that the only way to stave off the danger is through an interdisciplinary approach to the problem. This is because of the complicated nature of the problem of supplying society with water, a problem that concerns nearly all aspects of the relationship between nature and society.

The present paper touches in particular upon another characteristic of this problem, namely territorial differentiation. Every regional water conservation problem is linked on the one hand to one natural complex, determining the quantitative and qualitative features of the water resources available; on the other hand, the problem has to do with the type of production prevailing within the given territory and the characteristics of water-utilization and consumption.

In this way, the geographical aspects of water conservation manifest themselves in regular changes in the nature of the related problems.

The geographical aspects of water conservation problems in mountainous countries are complicated, above all, by specific instances relating to a third dimension of the territory, viz. hypsometry.

It is well-known that differences in hypsometry determine a number of the interrelated properties of the territory, forming part of one broad term, namely "mountains" and "mountainous conditions". The third measurement accounts for the specific conditions of life and men's productive activity, an overall consideration of which will certainly contribute to a better understanding of many geographical phenomena and processes. This is also equally valid for the problem of rational use, preservation and renewal of water resources.

The distinction between the water problems of mountainous countries and those in flat areas is made possible by virtue of a hypsometry of the territory.

Relying upon the hydrological and water conservation characteristics of the relatively small, yet typically mountainous arid territory of Soviet Armenia, the author has attempted to find out and evaluate the specific features of the geographical aspects of the water-economy problems that are associated notably with the mountainous nature of the country.

The mountainous conditions that have a direct bearing upon water conservation and call for special consideration, comprise the following elements: hypsometry, steepness of surface slopes, vertical ruggedness, horizontal ruggedness, exposure of slopes.

Although the above components of "mountainous areas" are closely interrelated and form one whole, each of them is also of specific value for the organization of water conservation.

For this reason the study of each of the elements is of no lesser significance than the integral account of their influence on water conservation.

Hypsometry and absolute height cannot in any significant measure affect the organization of water conservation, the influence exerted being indirectly through solar radiation, the thermal regime of the atmosphere and the Earth, the amount, seasonal regime and form of precipitation and the various parameters of evaporation. To be brief, the influence is due to the climatic factors determining the hydrological and hydrographic characteristics of water resources, as well as the natural conditions of water utilization and water consumption.

The subject of our investigation is Soviet Armenia. It is situated between 38°50' and 41°18' North, on the northern limits of the subtropical zone. Its average altitude exceeds 1,800 m above sea level and in position is continental. The difference between the lowest (390 m above sea level) and highest (4,090 m above sea level) points is 3,700 m. As indicated in Table I, only 1·9 per cent of the territory lies at an altitude of less than 800 m, whereas 40 per cent of the whole area is to be found above 2,000 metres. These features, together with its complex orography, specify the principal hydrometeorological characteristics of the territory; like most components of the natural environment, those features are subject to the law of vertical zonality.

While the humidity of the air in summer falls short of 17 mb in the low zone, it rises to 72 mb in the high mountain belt, i.e. about 4·2 times. In those zones the relative humidity is 30 per cent and 70 per cent respectively.

The total mean annual precipitation amounts to 511 mm over the territory of the republic, being made up of 200 mm in the low-lying zone and over 900 mm in the high mountain belt.

In the area under consideration evaporation largely exceeds precipitation, causing a great shortage of moisture especially in the low-lying belt, where the humidity coefficients (these are inversely proportional to the irrigation norms of agricultural crops) are 0·2 or so.

Thus, it can be stated that absolute elevation is not in itself a factor exerting a direct influence on the organization of the water economy. Rather, relative height in the form of declivities and surface ruggedness constitute such a factor.

We proceed from the proposition that hypsometry and steep slopes are among the prominent characteristics of the relief of mountainous areas. The steepness of slopes is to some extent indicative of the degree of vertical and horizontal dismemberment, being at the same time in causal relationship with hypsometry. Therefore, steep declivities reflect to some extent the whole range of relief conditions in the mountainous area and their influence on the organization of the water economy.

Take, for instance, agricultural irrigation (the significance of which for arid countries can hardly be overestimated) and resulting water erosion. It is well known that when the magnitude of declivities exceeds 2—3°, this in itself is a precondition for considerable soil outwash. Furthermore, a four-fold increase in declivity results in a two-fold acceleration in the velocity of running water. On the other hand, when the velocity doubles, the volume (weight) of the particles, that can be drifted away, grows nearly 64 times. For this reason the ploughing up of slopes steeper than 6—10° is inadvisable especially without taking special precautionary measures.

Experience indicates that slopes of up to 0·3—0·5° are most favourable for agricultural irrigation, when gravitational irrigation without additional measures is possible along both furrows (cotton and some root crops) and belts (cereals and other crops requiring no intercultivation). If the area has a declivity of 1·5° and over, gravitational irrigation becomes extremely difficult, and terracing of slopes or spray irrigation is required.

Steep declivities and ruggedness of relief give rise to technical complications in building and using an irrigation distributional network and the main canals.

Water supply for municipal and industrial purposes is likewise rather sensitive to relief conditions and declivities of 0·5° to 2° offer the best conditions for organizing the complex water economy of modern cities. If the declivities are either less than 0·5° (requiring the lowering of the entire sewerage system and the setting up of pumping stations) or over 2°, operation expenses and the cost price of new urban water-works soar.

The water conservation requirements of the Armenian SSR present the following picture. Adequate and satisfactory topographic conditions for the organization of watereconomy prevail in about 10—15 per cent of the Republic's territory. It comprises those areas of the surface where declivities lie within the range 0·5—3°. It should be noted that more than 70 per cent of the territory has inclinations exceeding 5° including 41 per cent of over 12° and 19 per cent in excess of 20° (Table I).

A special examination of the matter has led to the following suggested classification of surface declivities: up to 0·5°; 0·5—2·0°; 2—3°; 3—5°; 5—8°; 8—12°; 12—16°; 16—20° and over 20°. This has been found most suitable in the context of the economic estimation of the relief conditions of the territory, for taking into account the requirements of agricultural irrigation, water conveyance to pastureland, the organization of domestic water supply, sewerage and other aspects of water conservation.

Proper cartometric measurements have also been made and the data obtained indicate the distribution of various magnitudes of declivities, dislocations and exposures along vertical zones. When water-economy measures are taken, such quantitative findings enable us to envisage the problems of the topographic and hypsometric conditions of the locality.

The nature of the derived data is illustrated by the pattern of steep declivities listed in Table II.

From a comparison of the figures in Tables I and II it is possibe to derive a comparatively detailed picture of the characteristics of Armenia as regards steep declivities and their direct impact upon hydro-engineering measures

TABLE I

Certain characteristics of the mountainous area of the Armenian SSR

Hypsometry		Declivity steepness		Vertical dismemberment	
elevation above sea level in meter	per cent of total area	degrees	per cent of total area	depth in metres	per cent of total area
390— 500	0·1	up to 1	8·4	up to 50	24·3
500— 800	1·8	1— 3	10·4	50—100	11·9
800—1000	8·0	3— 5	10·9	100—200	23·7
1000—1500	18·3	5— 8	15·3	200—300	14·1
1500—2000	31·3	8—12	14·0	300—400	9·0
2000—2500	24·5	12—16	12·6	400—500	7·6
2500—3000	12·6	16—20	10·1	500—600	4·3
3000—3500	3·3	20—30	14·0	600—700	2·3
above 3500	0·1	above 30	4·7	above 700	2·8
Total in Soviet Armenia	100·0		100·0		100·0

Hypsometry		Horizontal dismemberment		Exposure of slopes	
elevation above sea level in meter	per cent of total area	extent of river valley network km/km²	per cent of total area	sides exposed to light	per cent of total area
390— 500	0·1	up to 0·2	5·8	horizontal plains	22·5
500— 800	1·8	0·2—0·4	9·2	northern	10·5
800—1000	8·0	0·4—0·6	14·7	southern	11·6
1000—1500	18·3	0·6—0·8	21·4	eastern	6·1
1500—2000	31·3	0·8—1·0	20·8	western	8·6
2000—2500	24·5	1·0—1·2	17·8	N—E	12·2
2500—3000	12·6	1·2—1·4	7·5	N—W	8·0
3000—3500	3·3	1·4—1·6	1·7	S—E	10·0
above 3500	0·1	above 1·6	1·1	S—W	10·5
Total in Soviet Armenia	100·0		100·0		100·0

TABLE II

Distribution of slopes of different steepness in the elevation belts (in percentage)

Declivity steepness in degrees	All Armenia in per cent	Including the elevation belts (meter above sea level)						
		up to 500	500—800	800—1000	1000—1500	1500—2000	2000—2500	over 2500
up to 0·5	100	0·2	1·2	49·5	13·2	26·1	9·5	0·3
0·5— 2	100	0·3	1·2	10·5	36·4	32·0	17·2	2·4
2— 3	100	0·2	0·7	17·5	23·5	29·7	22·6	5·8
3— 5	100	—	1·1	4·6	27·3	30·5	27·0	9·5
5— 8	100	—	3·1	1·9	13·0	28·1	29·9	24·0
8—12	100	—	2·6	3·7	19·9	28·1	23·3	22·4
12—16	100	0·1	1·8	4·1	16·3	31·0	28·5	18·2
16—20	100	—	2·2	5·1	19·6	27·3	27·8	18·0
over 20	100	—	1·7	3·8	15·8	25·3	30·5	22·9

as well as a consideration of the hypsometry and the relevant differences in hydrometeorological conditions.

Its mountainous nature greatly changes, by virtue of the surface properties referred to above, all the hydrological and morphological conditions and the basic parameters of the water resources of the territory.

The general elevation of Soviet Armenia is such that it constitutes a watershed between the rivers Kura and Arax. This accounts for the significant fact that all her water resources estimated at 15 thousand million cubic meters annually are of local origin. The central regions of the Armenian highland in Turkey feed only the boundary rivers of Arax and Akhurian.

Evaporation amounts to 57 per cent of the consumption side of the Republic's water balance, the remaining 43 per cent being made up of surface and underground water run-off. The mean specific discharge of the river basins vary from 1 to 13 litres/sec per sq.km, and the range grows to 25 l/sec per sq.km in the higher mountain belt.

In the evaluation of relief conditions for the organization of water conservation, the area of catchment basins and the relative height of watersheds are of no lesser importance. It is precisely those factors that specify many of the elements in the technical solution of the regulation and inter-basin conveyance of water and the distribution of water resources between industrial and domestic consumers.

As the territory of the Republic is rugged, the average size of the main catchment area is a little over 1,200 sq.km, while the elevation height of the watersheds between the first order rivers is predominantly above 1,000 m, attaining in certain cases 3,000—3,500 m.

In order to describe and evaluate the geographical aspects of the water-economy problems of mountainous territories, hydrological data should also be analyzed from the point of view of water consumption and utilization, discharge into rivers, the annual distribution of flow, the quality of water, and the hydro-energetic potential of rivers which cannot be dwelt upon in detail here.

All the considerations set forth above concentrated upon the territorial characteristics that are determined by the third dimension — hypsometry, and impart specific features to the water economy of arid mountainous countries. It stands to reason that they should be reflected in the scientific results obtained from a geographical investigation of water conservation, i.e. in the regionalization of water conservation.

The facts available from the exploration of the Armenian SSR indicate that the regionalization of water-economy can be of great practical value if both horizontal and vertical territorial divergences in the natural and economic conditions of water conservation are considered as comprehensively as possible.

The catchment areas with relatively independent water and water-conservation balances, as the results of the studies have shown, are taxonomical units of first order. There are eight such water-conservation regions in the Armenian SSR. The prognoses for 1980 and 2000 show a considerable shortage in the water-economy balance in a part of those regions. The interregional redistribution of water resources is a means of partially making up for the above deficiency.

The interregional problems are related specifically to the hypsometrical steep declivities of the catchment basin. We have regarded the elevation belts marked out within the catchment basins as subregions, i.e. as the second step on the taxonomical ladder of water-conservation regionalization. The pronounced zonality within every regional catchment basin not only automatically determines the water-conservation conditions in every subregion of a particular belt, but also gives rise to new interrelationships between the territorial zones. The subordination of the lower to upper zones is a distinctive feature of the water economy of mountainous countries.

Three or four subregions are marked out in every water-conservation region of Soviet Armenia.

Special geographical research into the aspects dealt with above and their overall consideration within the experience of water-conservation constructions in mountainous countries, will no doubt consolidate the scientific basis of the utilization of the natural environment by society and the preservation and renewal of one of its basic components, namely water resources.

DRY PERIODS IN MID-LATITUDE HUMID REGIONS

by

E. NEEF

The drought of 1969 has focused the interest of scientists on this phenomenon and its effects on natural processes and on economics. In Central Europe dry summers are relatively frequent, but seldom lead to critical situations. Therefore any special adjustment to these events did not seem necessary. The increase and concentration of technical activities, both in industry and agriculture will lead to such events having consequences of economic and general importance more frequently in the future.

We have sufficient information about frequency, duration and intensiveness of dry periods because the European countries dispose of well organized meteorological services. But meteorological data alone do not give the needed statements about the effects of dry periods on the natural balance and their economic disadvantages since these effects are based on the interdependence of several different kinds of factors. Economic development, the location of industrial plants, the concentration of population in large settlements and their technical equipment, and other factors may influence the regional peculiarities of the sequence of a dry period.

Therefore the problem embraces more than just physico-geographical aspects; it becomes a problem of "Man and Environment". In this context the following notes will outline three increasingly complex stages of the problem.

DROUGHT—SOIL MOISTURE—PLANT GROWTH

There is a well-known relation between drought and soil moisture. In longer dry periods soil moisture decreases to a critical degree (i.e., to wilting point) and so it is no longer sufficient for plant growth. The yield of crops diminishes; the danger of a bad harvest is greater the later the fruit ripens. Much experience and statistical data exemplify this rule.

DROUGHT—GROUNDWATER—STREAM FLOW

Another relation exists between drought and groundwater. As summer is regularly the peak time of evapotranspiration, in that season replenishment of the groundwater body is very small or nearly zero. The failure of rain cannot be the cause of the reduction in groundwater. It is rather the flow of groundwater to the rivers, having a low level in summer. This flow compensates for the lack of stream flow and river discharge diminishes by less than if it simply reflected the deficiency in precipitation. Therefore, we may often notice that in the first dry year the water-level of rivers remains relatively high. But if the recharge of the groundwater in the winter months is likewise insufficient, the second year is the year of extremely low water-level, even if precipitation attains the average. This means that the deficiency of soil moisture, the greatest shortage of groundwater and the response in river flow does not coincide in the same year. We may distinguish two cases: (a) the simple case of a reduction of soil moisture and fertility and (b) the more complicated case of general dryness with regard to both agriculture and water supply, often realized in the second of two years with insufficient precipitation or in a dry summer if groundwater was deficient in the preceding year.

In the first case the effects of drought are limited to agrarian production. In the other case the consequences extend to all human activities needing a supply of water as for instance: drinking water, industrial water, irrigation water, water for navigation, water needed for hydroelectric plants, etc.

In many branches the scarcity of water leads to a restriction of production and to economic losses. In addition, it enforces special and expensive action to guarantee as much production as possible and costs become higher. It is possible to calculate these losses and to estimate the economic effects of dry periods not only for single branches of production, but also for limited parts of or for the entire country. Case studies show that the circumstances of such events differ not only from place to place but also from time to time.

An extreme example of drought was reported from the eastern Erzgebirge. In the late summer the wells drawing water from the 2—4 m thick layer of periglacial debris overlying the bedrock of gneis and granite dried up. The water supply had to be guaranteed by transport. Only after precipitation and the melting of a thin snow layer had furnished enough water did the critical period come to an end in February 1970. The economic losses above all depend on the fact that the Erzgebirge is a recreational region and some villages were therefore induced to limit the number of tourists.

THE IMPACT OF NEW TECHNOLOGIES

A new complicating aspect to the problem arises when we consider the future, for the impact of man will increase with the development of new technologies. The characteristics of these new technologies will be: (1) the concentration of production with still greater rates of dangerous emissions in limited areas; (2) the concentration of population in the larger settlements and conurbations with a high standard of life and thus a serious increase of the amount of solid wastes in the towns; (3) the increasing aggressiveness of the chemical wastes from industry, towns, and agriculture, because of the trend of chemical production toward more effective substances. A good deal of these wastes reach the lakes and rivers, and generally the rivers are the main routes of waste transport. All these wastes consume the oxygen in the water and lessen this crucial basis for organic processes to a critical minimum, where life cannot exist. In most countries governments have limited the admissible input of detrimental substances into rivers, related to the average minimum discharge

NQ. But in dry periods the discharge is often smaller than NQ and the emission of the allowed quantities of waste causes heavy disturbances in the biological and energy systems of rivers. Single events of this order of magnitude may destroy the work of many years. Nowadays the number of such extreme events in agrarian regions is small and we notice critical situations in only a few cases. Surely, we must except that corresponding to the future development of new technologies in agrarian production the danger will essentially increase. The continuous growth in the application of chemical fertilizers and pesticides, the trend to industrial modes of agrarian production, especially the development of large poultry or cattle farms, and the enormous discharge into rivers when cleaning fodder silos, also increase the impact of man in regions little effected up till now.

Natural hazards during dry periods in Europe illuminate the coming problems since they anticipate the future menace of the increasing impact of man. Generally speaking, the relations between natural processes and human activities will permanently change and this change will more and more frequently bring about critical situations. Without a prognostic insight the right adjustment of man to the phenomenon of dry periods in humid climates will not succeed.

Three stages of complexity have been described, each being characterized in a special context. But the higher the degree of complexity, the greater becomes the influence of natural factors. J. Schmithüsen (1948) has pointed out the general tendency that the influence of drought on agrarian economics increases in correspondence with the progressive share of fodder and roots harvested in autumn when the normal effect of drought is at a peak. The economic losses above all depend on the revenue from animal products.

In other fields of human activity (e.g. the spatial organization of towns) we may state the same. During the generalization of various experiences we may set up for discussion the following thesis:

Increasing perfection of spatial organization and increasing utilization of natural resources leads increasingly to reductions in the possible actions against natural hazards and to increasing costs of management to preserve sound environmental relationships. The more advanced the management of regions, the larger the constraints on decisions. We may interpret these phenomena by means of the principle of "entropy". In doing so, we discover a useful approach to all environmental questions based on the conception of environment as a material or energy system. Natural processes and human activities can be related to the same processes of exchange in respect of transformation of matter and energy. The evaluation of economic effects caused by natural hazards may be less difficult.

UTILIZATION OF FLOODPLAINS AND RUN-OFF WATER. CASE STUDY: NEGEV, ISRAEL

by

E. Y. KEDAR

THE SURVEY

A survey was carried out in the Negev Mountains (Fig. 1), where an area of 2 million dunams (one and a half million acres) of desert land was mapped. Included in the mapping were floodplains and their respective watersheds, the divide lines, dams, canals and ruins of ancient settlement of the population who practised that run-off water and floodplain agricultural system. Results of the survey were published in 35 maps (scale of 1 : 20,000, Fig. 2) as an appendix of this writer's monograph (Kedar, 1966). The mapping also contained the general hydrographic net of the Negev Mountains. Parallel to the general mapping, 30 floodplain farms were surveyed and mapped, in detail, in order to study the hydrotechniques of those farmers and the methods of flood water utilization. This survey was made on a scale of 1 : 1,000 to 1 : 2,500 and are exact to one centimeter (Figs 3 and 4).

SOURCE OF WATER

The only source of water which was available to the inhabitants of the Negev was the run-off water from episodic showers. The farmers erected an elaborated system of canals, dams and cisterns to capture, conduct and conserve the surface flow water (Fig. 5). The episodic showers fell on a maximum of some fifteen days out of the year, producing run-off that lasted for a seasonal total of twenty hours at best (Tables I, II and Fig. 6.). It is this flow that the settlers had to capture and conserve all year long. Unlike most settled arid lands, no perennial water, from springs, wells or exotic rivers were available in the Negev. Therefore, the farmers in the Negev were of a desert rather than an oasis type.

The settlers highly adjusted their functions to watershed limits. Boundaries of the peripheries of the farms coincide with divide lines of watersheds. Watersheds supplied the settler both with water for his cisterns and with silt for his gardens. Therefore, the stony, dry Hamada slopes, and the mountain sides were considered to be the source of life in the Negev comparable to the water and silt supplied by the Nile River. All the mountain slopes in the area, and in particular every inch of uncultivated slope in the vicinity of the cities were fitted into this run-off-gathering system. Each part of the fields was allotted the run-off from a definite section of the slopes. Only those patches of soil which were in a topographic condition such that run-off water could be conducted to them by gravitation were cultivated. A ratio of 1 to 12 between the area of the field and the respective watershed

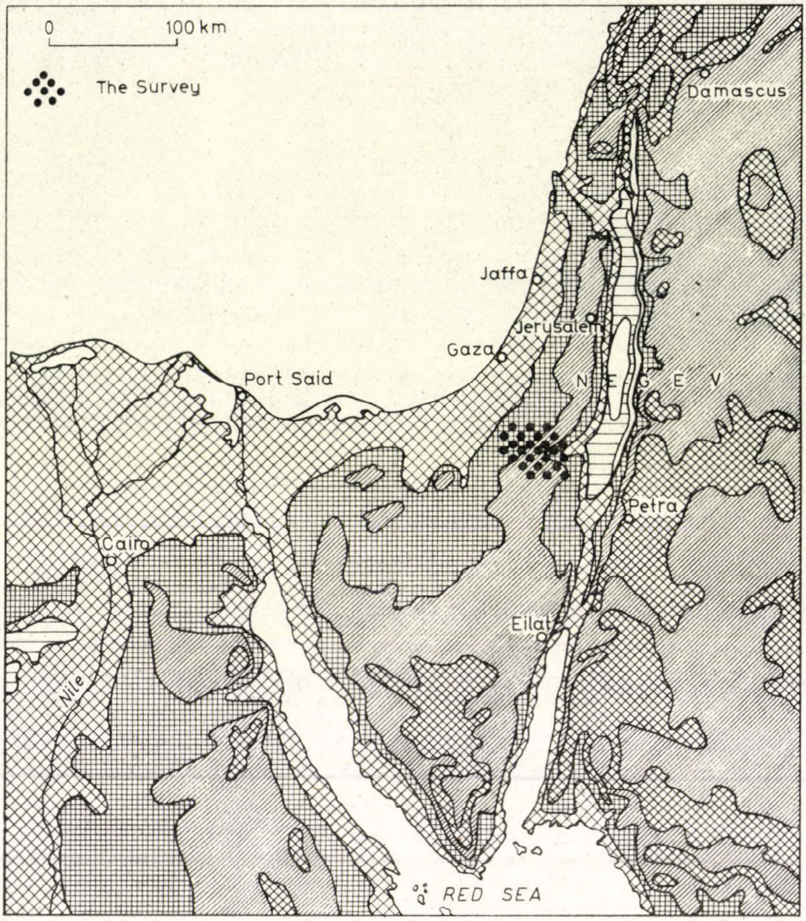

Fig. 1. Orientation map

was required to supply the moisture at a depth available to roots of the crops. Patches of soil lacking this ratio was not involved in agricultural production for the city. The field/watershed ratio fluctuated according to two parameters: the relief and texture of the crust of the surface of the watershed. The more moderate the relief, and the more permeable the crust of the watershed, the smaller the ratio was and vice versa (see Table II). The field/watershed ratio fluctuated in the area under study between the mean average of 1 to 9·4 (large) and the mean average of 1 to 47·8 (small). The ratio was modified by the settlers who changed the natural hydrographic net by using either collecting or diverting canals which added or subtracted water to or from the natural flow in the watershed (Fig. 7). Using the average of $R = 1 : 12$ and the total area under cultivation in the Negev Mountains as a whole, at the peak of

Table I

Number of rainfall days in the Negev

Station	Recording period	Cumulative number of rainfall days for period, according to depth (mm/day)				% for period according to depth (mm/day)			Average number of rainfall days/years	% days/year Starion Beersheba
		0—2·9 mm	3—10 mm	>10 mm	Total	0—2·9 mm	3—10 mm	>10 mm		
Mamshit	1941/2—1947/8	46	56	16	118	39	46	15	16·9	46
Beersheba		126	93	40	259	46	39	15	37·0	
Sedeh Bôqer	1951/2—1958/9	100	38	18	156	64	24	12	19·5	52
Beersheba		151	81	49	281	54	29	17	35·0	
'Avdat	1960/1—1964/5	41	33	13	87	47	38	15	17·4	42
Beersheba		116	58	34	208	56	28	16	41·0	

Table II

Precipitation records for the Negev

Station	Recording period	Average rainfall P (mm)	Max. annual M (mm)	Min. annual m (mm)	Quotient of variation Q*	% Range of variation, VR*	% Relative vari-ability Vr*	Coeffi-cient vari-ability Vc*
Revivim	1943—63	101	178	33	5·3	143	32	38
Beersheba	1943—63	180	293	42	7·0	133	26	33
Sedeh Bôqer	1951—63	76	137	23	6·0	150	39	45
Beersheba	1951—63	168	293	42	7·0	141	34	41
'Avdat	1960—65	95	159	28	5·7	137	56	60
Beersheba	1960—65	202	339	42	8·0	147	50	54
Mamshit	1942—48	135	191	58	3·3	96	28	37
Beersheba	1942—48	195	291	108	2·8	94	28	30
Beersheba	1920—65	195	339	42	8·0	152	30	35

* See text for explanation.

Quotient of variation, $Q = \frac{\mathrm{M}}{\mathrm{m}}$

% Range of variation, $VR = \frac{\mathrm{M} - \mathrm{m}}{\mathrm{P}} \times 100$

% Relative variability, $V_r = \frac{1}{\mathrm{n}} \Sigma_{d_i} \times \frac{100}{\mathrm{P}}$

Coefficient of variation, $V_c = \frac{100}{\mathrm{P}} \sqrt{\frac{1}{\mathrm{n}} (\Sigma_{d_i})^2}$

where

M = max. annual rainfall for the period, m = min. annual rainfall for the period, P = average annual rainfall for the period, d_i = deviation (from the average), n = number of years in the period.

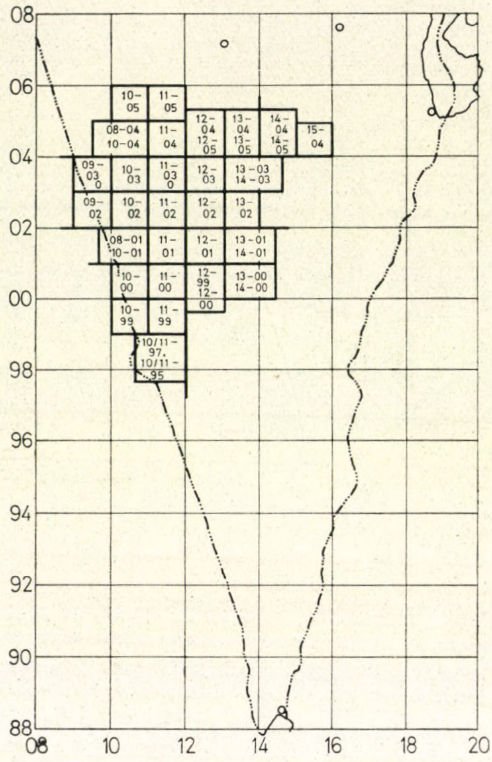

Fig. 2. Index map of the Survey

the settlement, when farming activity culminated in the cultivation of 50,000 dunams, the total area of the watershed involved in the irrigation was 600,000 dunams. Thus, the rest of the area supplied water which was surplus and over and above the amount needed either for domestic use or for gardening. Thus, although it seems strange, the settlers of the Negev Mountains had more water than they could utilize (Fig. 8 and Tables III and IV).

The major problems that confronted the ancient farmer were the technique of using the surplus water and the extension of the farming land. From the survey data and field study observation it is obvious that about 20 per cent only of the land which was used by the settlers was land naturally qualified for gardening, such as alluvial terraces, plains and accumulated silt in the stream beds in the required ratio. The remaining 80 per cent was soil which had been accumulated by man-made devices which induced the process of soil deposit, such as check dams (Figs 9 and 10). Thus, at the beginning, the field/watershed ratio was small, but was enlarged gradually with the population growth by artificial or man-made accumulated silt. The disposition

Table III

Distribution of farmlands in the Negev (in dunams and percentages of watershed area)

Region	Area, sq.km	Farmlands, Dunams	Per cent of farmland of the total area
'Avdat	125	6,784	4·5
Shivtah	188	4,945	2·7
Nitzana—Beerotaim	170	14,893	8·7
Halutza—Rehobot	158	2,385	1·5
Sde—Boker	255	3,026	1·3
Mamshit	62	420	0·7
Revivim	279	2,269	0·9
Lotz—Haresha	423	1,999	0·5
Ruth	92	2,368	2·5
Leana—Yeter	224	950	0·4

Table IV

Function of environmental parameters (relief and texture)

Region	Elevation, t_1	Lithology, t_2*	Precipitation (mm)	Ratio $= \frac{F}{W}$
Nitzana	225 to 275	S + L	90	22·5
Shivtah	300 to 350	L + R	90	14·0
Revivim	375 to 400	S + L	120	32·7
Sde—Boker	400 to 450	L + R	70	17·1
'Avdat	450 to 800	L + R	120	12·0
Mamshit	600 to 650	S + L	100	26·6
Lotz	950 to 1000	L + R	150	11·0

* S = sand, L = loess, R = limestone rocks.

of canals on the slopes, the check dams in the stream beds as well as the presence of *heaps of stones* torn from the desert pavement in order to facilitate erosion, make it abundantly clear that no slope was left unutilized and no stone unturned to keep up with population growth in the Negev, and the need for more available land.

THE SOURCE OF SOIL

While everyone recognizes the various purposes for which the canals and dams in the central Negev were built, opinions are divided on the function of the rows upon rows of heaps of stone on the hill slopes. Investigators are agreed only on the correlation of these mounds with the cultivated valleys, which are never very far below, and on their apparent consequent connection with agriculture. The mounds are small and round, consisting of stones heaped

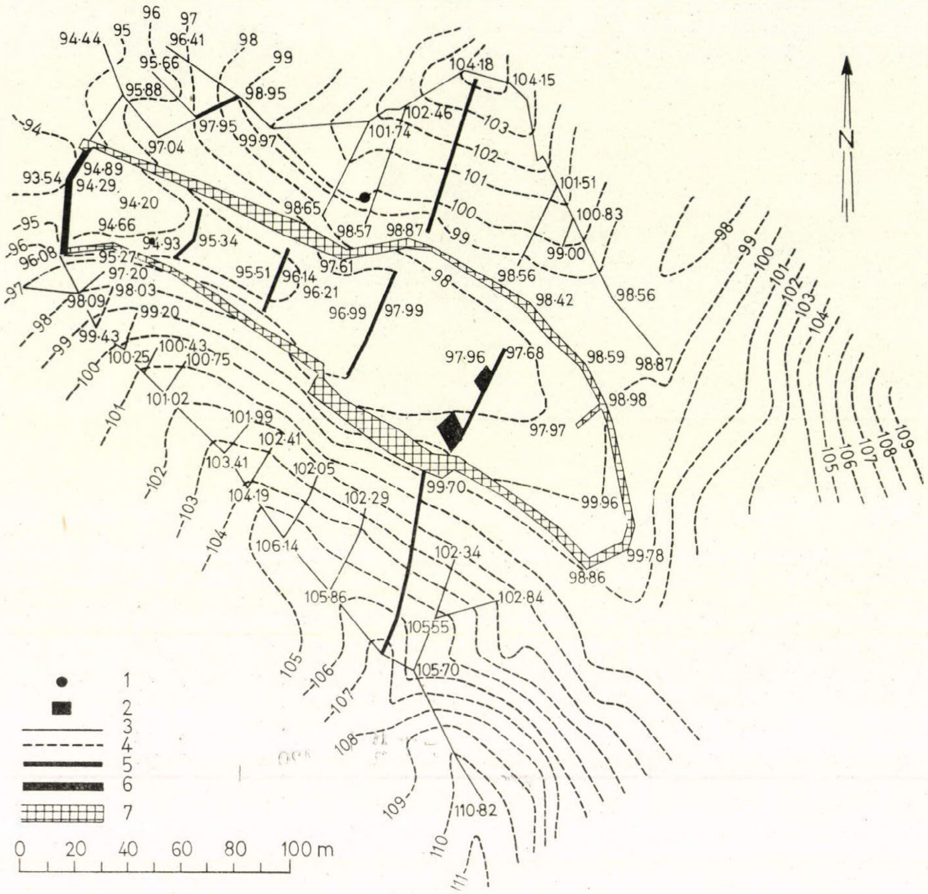

Fig. 3. Floodplain in stream bed
1 — Control point; 2 — Ruin; 3 — Spillway; 4 — Relative contour lines; 5—Retaining wall; 6—Dam; 7—Fence

or laid to a height of 70 centimeters and a diameter of 1·5—1·7 meters. The stones are of the same kind as the ones that happen to litter the ground in the immediate vicinity—limestone, flint, or any other rock. There are hundreds of thousands of these mounds in the central Negev. In the Ovdat district they occupy 2500 hectares out of a total area of 130 sq.km. This is three times as much space as the 750 hectares that were devoted to cultivated land. They are invariably found on slopes above the cultivated valleys, but never inside the valleys, and they never occur singly but always in groups, their number rarely departing from an average of eighty to the hectare. They are laid out in perfectly straight rows, with shallow canals or raised furrows running down between every row and the next. On an aerial photograph, the pattern resembles a mosaic or a geometrical design. The direction of the rows is almost identical with that of the slope. As has been said above, investigators

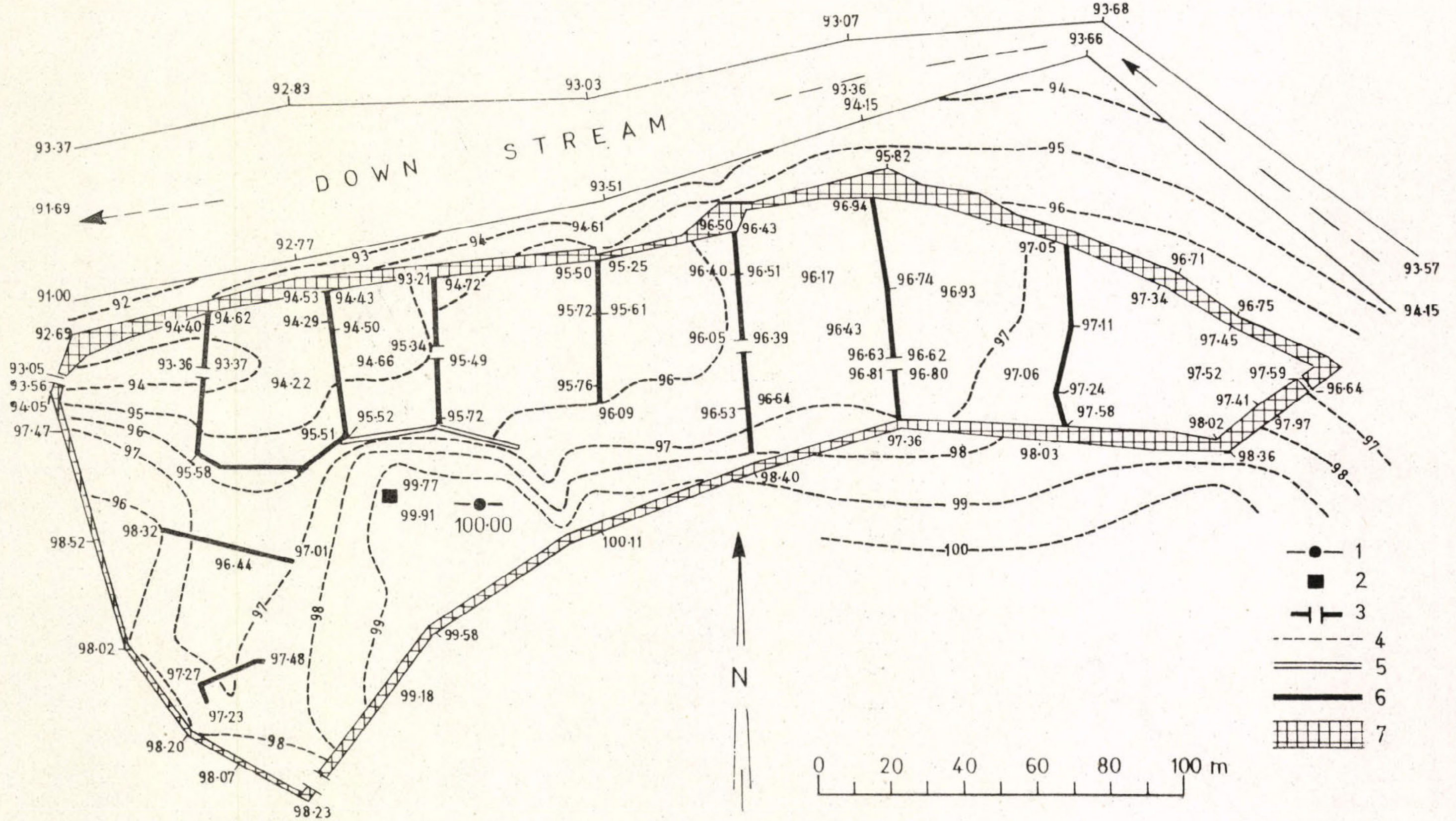

Fig. 4. Floodplain on a stream terrace (legend see at Fig. 3)

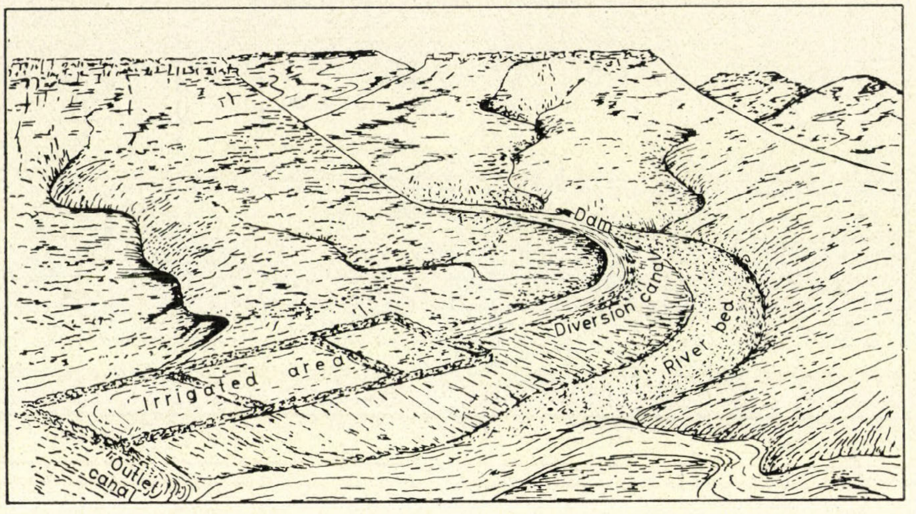

Fig. 5. Schematic plan of watershed management in the Negev

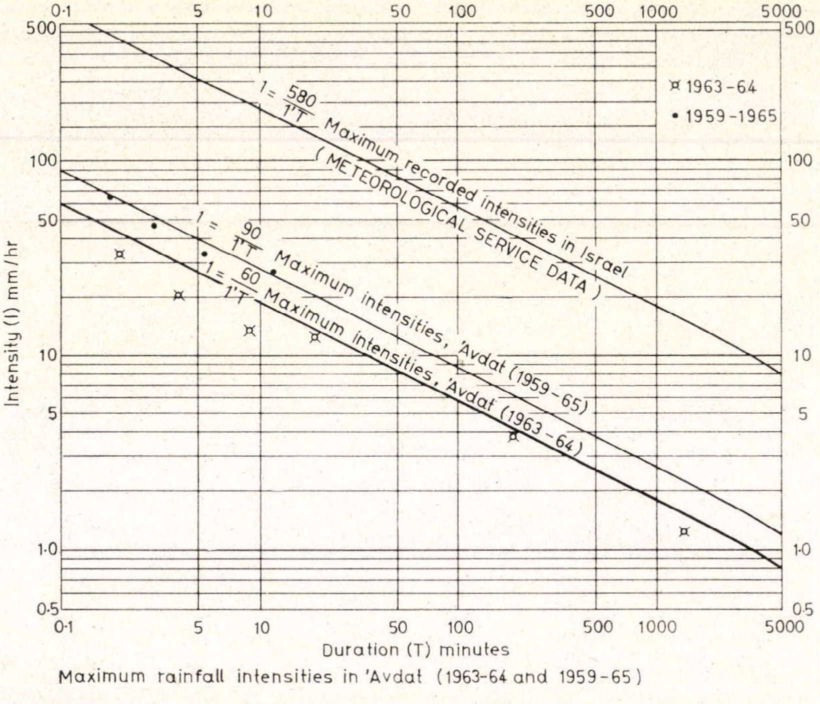

Fig. 6. Maximum rainfall intensities in the Negev

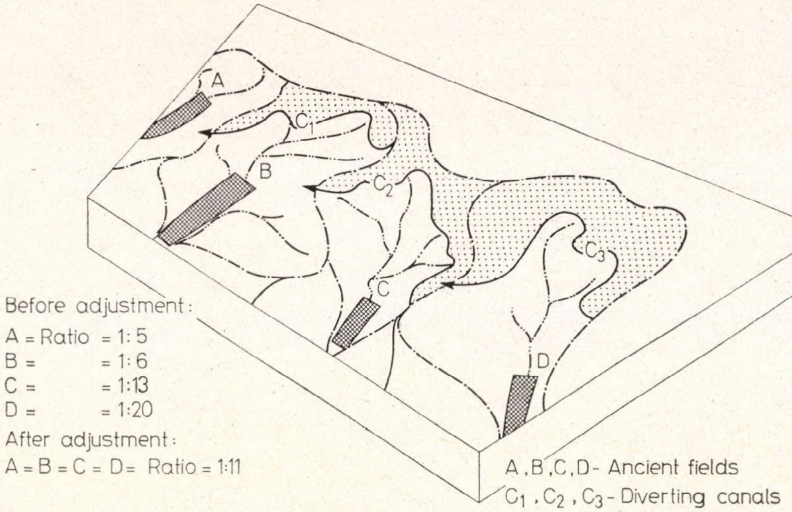

Fig. 7. Adjustments of watersheds to given fields

disagree about the agricultural function of the fields of mounds. Some believe that they were all vineyards, finding support for their view in the Arabic name for these fields, which is tuleilat el anab or rujum el kurum (vine mounds) (Woolley and Lawrence, 1914). Others, who share this view, explain that the mounds were meant to exert a microclimatic influence. Others yet believe that the mounds are simply heaps of stones removed from the area in order to prepare it for cultivation (Lewis, 1948; Kirk, 1938, 1941; Colt, 1936; Lowdermilk, 1953). All these views overlook the fact that the average annual rainfall in the entire region where the mounds are found is below 100 mm. This is far from sufficient to grow grapes, or any other fruit, without irrigation.

Any possibility of irrigating the fields of mounds, on the other hand, must be dismissed in the light of what we know about the water resources of the region then as today. The mystery of the mounds will be solved, however, if we consider it in conjunction with another puzzle — the origin of the prodigious amount of eroded soil that was washed down into the wadis and created cultivable plots behind the dams when man began to modify conditions of natural drainage. The bed of one wadi section, for instance, with a catchment area of 54 hectares, has been found to contain 20,000 cu.m of alluvium; into another, draining 73 hectares, have been silted 24,500 cu.m.

It has been calculated that at the yearly erosion rate of approximately 0·8 mm which can be taken as average in these regions (The sediment problem. *Flood Control Series*, No. 5, U. N., p. 12, 1953), the men who dammed the wadi beds would have had to wait for four centuries before the soil on their newly-created fields was deep enough to grow anything on — if they had depended on nature alone. To build a sufficient soil column inside the wadi

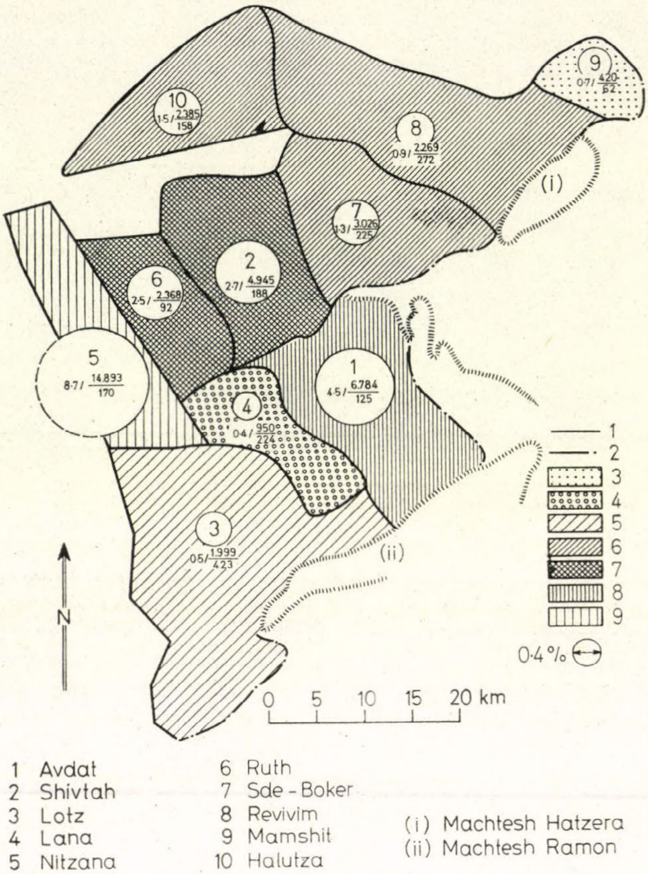

Fig. 8. Map of the distribution of floodplain farmlands in percentage of the Negev major watersheds

1—2 — Boundaries of the watershed; 3—4 — < 0·4; 5 — 0·5—0·8; 6 — 0·9—2·0; 7 — 2·1—2·9; 8 — 3·0—4·9; 9 — > 5%

within ten years of the damming would require a yearly erosion rate of 32·8 mm, which would be fantastic indeed under natural circumstances.

This is where the mounds come in. They were created when man decided to speed up the processes of natural erosion. In order that the slopes should supply him with run-off water and soil, he opened the desert pavement and broke the crust that covers the softened soil underneath. He thus created new conditions for the erosive forces which from now on could wash down the soft soil onto the wadi grounds. This process was originated only by active intervention of man.

To lay bare the soil and then allow it to be washed off unhampered into the canals which directed it onto the cultivated plots below, the ancient farmers had to rake together or pick up the stones that formed the hamada cover,

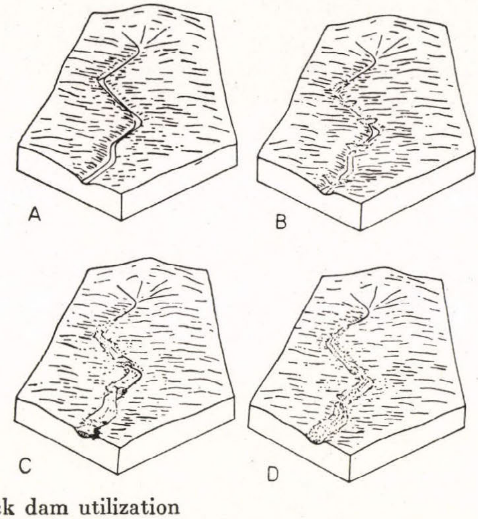

Fig. 9. Stages of check dam utilization

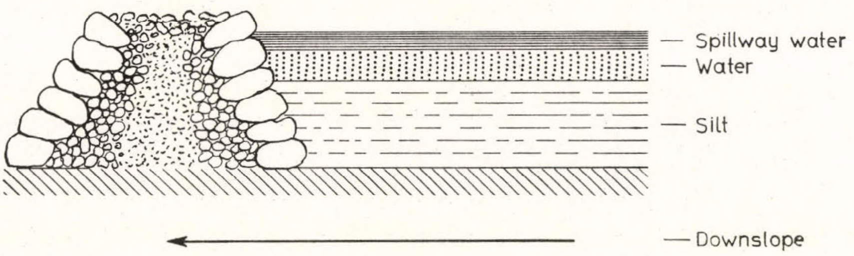

Fig. 10. Schematic cross-section of a dam

and the logical thing to do was to heap them into mounds. The mounds, then, had an origin but not a function. They served no purpose in themselves in ancient agriculture, they were simply dumps of material to be cleared from the ground. They were the by-product of man's endeavour to create cultivable land where the probability of run-off would be highest when it rained somewhere in the area — to bring together soil and water, the two fundamental elements of agriculture, at the most favourable spot. This interpretation is borne out by the invariable correlation of fields of mounds above and cultivable plots below (Kedar, 1957).

THE EXPERIMENT

In the course of the research on the run-off utilization in the Negev, the conclusion was reached that in order to deepen our knowledge one has to solve the problem of the mounds (Tuleilat el Enab) experimentally. For this purpose, seven experimental fields were established. The establishment and operation of appropriate fields represent the main part of the research carried out. Our aim was to find the purpose of the mounds within the framework of the ancient agricultural planning. The fields were installed according to the principle of comparing measurable erosive-fluviatile processes between an area where the natural conditions have been preserved, and an area where these conditions have been disturbed by man. Every experimental field was divided into two plots equal in area and slope. One plot was left in its natural state, whereas in the other the natural equilibrium was disturbed by clearing it from stones and heaping these in mounds. Every plot drained into a separate hole by a separate canal. Empty barrels were put into the holes for the purpose of collecting the water and silt in order to allow for a comparison of the results of soil erosion in the two plots. The connection between the canal and the barrel was established by means of collectors made of tin, which received the water and the silt from the canals and carried them into the barrels. Each one of the experimental fields was surveyed and mapped on a scale of 1 : 250.

In order to overcome the lack of exact data about precipitation conditions in the regions of the fields, three small totalisers were attached to each of the experimental fields for obtaining the following data for the completion of the research:

(1) Measurement of the amount of annual precipitation in each experimental plot.

(2) Calculation of the percentage of run-off within the total amount of precipitation, i.e. calculation of the coefficient of flow.

(3) Measurement of the amount of alluvium in the barrels.

(4) Calculation of the alluvium coefficient compared with the amount of run-off.

As the gradient of the slope influenced considerably the three factors 2—4, and in order to obtain a general picture of the natural conditions in the Negev, the fields had been concentrated in one place but were distributed in the following three regions: Shivta, Ovdat and Kefar Yeruham, with different slope conditions in each field. We concluded from the experiment that:

(1) The largest amount of precipitation measured was 111·7 mm in the plateau of Ovdat and the smallest amount 77·8 near Sedeh–Boqer. Ten totalisers measured more than 100 mm. The run-off ratio during the whole season was 20—25 per cent of the total precipitation amount.

(2) The amount of alluvium carried by run-off, sheet erosion and gully erosion, was slightly more than 1 mm soil, i.e. more than one cubic meter per dunam.

(3) The amount of alluvium mentioned which indicates a more serious erosion on the mounded plot than on the natural one, and the large amount of alluvium collected in the barrels supports our basic hypothesis that the mounds of piled-up stones had the purpose of increasing the rate of erosion on the hill slopes by disturbing the natural balance of the area. The alluvium obtained was diverted by various means to the plots where it accumulated and created the agricultural soil which was lacking in the region. The creation of soil for agricultural cultivation seems in our opinion to be the basic aim of the erection of the mounds.

CONCLUSIONS

(a) No crops could be grown by rain alone, and no permanent source of irrigation water was available. The ancients irrigated their fields exclusively by surface run-off channeled from adjoining slopes or wadies.

(b) All loessy floodplains, on which sufficient run-off could be concentrated, were terraced by the ancient farmers, so as to prevent erosion.

(c) In areas of dense habitation, the total surface area of the desert was subdivided into small catchments, each providing run-off for a definite farm area.

(d) Small catchments, where a higher percentage of the run-off can be collected were often preferred to large catchments, where much water is lost by percolation into the pebble of the wadi beds.

(e) Each catchment was subdivided into small strips, so as to break up the run-off into several small flows. The smaller flows could be more easily controlled by the farmer and be distributed inside the farm according to his needs.

(f) In all areas of dense population, soil erosion was increased by clearing the surface stones. The silt was accumulated by the check dams in the stream, leveled off and cultivated.

(g) A mean ratio of about 1 : 12 (range of 1 : 9·4 to 1 : 47·8) exists between the catchment area and the cultivated land; 12 hectares of slope were needed to irrigate one hectar in the floodplains.

(h) As about 2400 cu.m of water were at least given to a hectar of field crops, this is to mean that each hectare of slope yielded about 200 cu.m of run-off.

(i) It is evident that the overall rainfall in the past was substantially the same as it is now (about 100 mm); thus, about 15—20 per cent of the total annual rainfall was exploited as run-off for irrigation. Relatively small fluctuations and a shift of rainfall pattern may have somewhat changed this percentage; this question is now under study.

(j) Hydrological observations have shown that a rain of about 7—10 mm/hr intensity, even if only 3 mm of it fall within 20—25 minutes, is sufficient to cause the formation of run-off and the concentration of floods, provided that the ground is wet from previous rain.

(k) The inhabitants elaborated a very sophisticated water utilization system and soil conservation method, but were still limited to the cultivation of no more than 3 per cent of the total area. The major limiting factor for water and land utilization seems to be not merely the aridity but the mountainous relief and lack of soil. Lack of arable land reinforced the local limitation, which was already enhanced by aridity.

(l) Archeological studies undertaken in parallel to our work have shown that the flood-water utilization dates back at least as far as 300—400 B. C., but possibly to 1,000 B. C. It was practiced intermittently by different civilizations, till the end of the Byzantine Empire, in the 7th Century A. D.

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CORRELATION BETWEEN THE INDUSTRIAL ZONES OF BUCHAREST CITY AND THE POLLUTION OF ITS ATMOSPHERE

by

C. HERBST, E. DUMITRESCU and V. DUMITRESCU

The functional structure of Bucharest with its numerous industrial zones, its main roads and railway arteries has seriously polluted the atmosphere.

The present grouping of the functional zones in Bucharest had been moulded by the different periods of that capital's historical development. In the beginning, the central core of the town was a market situated in the place of the present St. Gheorghe square.

With the increasing commercial activities of the ancient market the handicrafts and industrial units established, and Bucharest having become the capital of Romania, the city underwent a rapid development and modification of its internal structure. In this way, first industries and then residential quarters gradually came into being around the central commercial core of the city, especially along the Dîmboviţa and the main roads. Again it is in the proximity of the central core that the administrative buildings have been erected.

The northern part of the capital consists of modern residential quarters, while lakes and parks are situated alongside the Colentina river. Gradually zones associated with the railway transport came into existence, the most extensive ones being situated around the North Railway Station comprising workshops, stores and factories that are necessary for railway transport. Later, the area around this zone came to be covered with residential quarters which now lie within the perimeter of the city. The other railway transport zone in the perimeter of the city has developed around the East Railway Station.

Other zones lying outside the boundaries of the capital should also be mentioned. They ensure connection between the different belt railway lines and they are serviced by the other four railway stations. Up to quite recently, another railway station, that of Filaret, has been functioning in the centre of the capital. It has now been discarded, owing to the intense air pollution and traffic congestion it caused.

Besides the railway transport zones, Bucharest also has a whole series of road arteries which facilitate the motor transport connecting the various districts both with one another and with the neighbouring zones of the city.

The present location of the various functional quarters gives a true picture of the way the city has developed in the course of time. Until quite recently, industry was distributed throughout almost all of the city. The commercial zones were centred around the old market and along the major thoroughfares.

The green open-air zones were mostly set up in the northern part of the capital where the better-off classes lived. The rest of the area was covered either by residential quarters or by green space. The densely built up central zone which is to be found inside the ring made by the main thoroughfares is a characteristic feature of the capital of both today and yesterday.

The systematic planning applied to the structure of the city as a whole has begun to correct the old trend. In the achievement of this systematization the prerequisites essential for industrial, commercial, and communication activities have been first taken into consideration. Considerable attention has also been paid to all the necessities of a modern city where the steps taken against air pollution, the noise control, and the removal of traffic congestion play an important part. Thus, during the last two decades the residential quarters have been extended towards the suburbs where the new constructions look like new small satellite-towns. Among these quarters mention should be made of the Floreasca, Pajurei, Titan, Drumul Taberei, Militari, Berceni and Sergent Niţu Vasile districts.

With the same purpose, industrial units have been grouped into larger zones and those harmful to health have been transferred to more suitable places. Thus, for instance — the "Titan" cement works which had the highest air pollution coefficient in the city have been transferred. Producing some 2,000 gr. of dust per cu.m of air this factory used to lie in the prevailing direction of the wind so that the atmosphere of the neighbouring quarters up to a distance of 3 km was polluted. In order to avoid this kind of situation, the new industrial plants have been placed in the south and south-west part of the capital in the suburban areas. In this way the problem of the air pollution caused by these plants has been solved.

To improve the air quality, measures have also been taken to enlarge the area of green open-air spaces. Zones devoted to recreation and entertainment such as the parks of the Exhibition, of Youth, and the 23rd of August park, as well as a whole series of green areas have been set up, and they play an important part in the scenery of the city.

An analysis of the structure of the functional areas in Bucharest has shown that a number of industrial and railway transport zones are located in the central, densely populated part of the city. This has raised a number of health problems, among which the pollution of the atmosphere by smoke, noxious gases and other impurities is of particular importance.

Investigations into the quality of the air in the various zones of Bucharest have emphasized the fact that many of the industrial works and railway stations lying in the centre of the city produce a noxious atmosphere.

Among these industrial works of the capital that are responsible for a maximum of pollution are the thermal power plants as well as the factories producing building materials, chemicals, and pharmaceutical products and those processing animal products.

It is within the four largest industrial zones of the town situated in the east, south and south-west, west and north-west and in the transport zones, that the highest quantities of impurities have been recorded.

The map recording air pollution in Bucharest shows that highly air polluted areas directly overlap the industrial and heavy transport zones of the city. Dust deposited in these areas attains an average value of 464·4 tons per sq.km yearly, while the average values for other parts of the city are as low as 280 tons per sq.km per year.

Among the intensely polluted zones the one lying around the "23 August Works" should be mentioned. The degree of pollution is also high in the central zone where although there are no industrial works, motor traffic is dense.

The third strongly polluted zone is the one lying around the East Railway Station where large number of industrial plants are located and where railway and road traffic is heavy.

Other polluted zones lie around the North Railway Station. The southern and south-western zones of the city show lower pollution values.

Although the zone in which the slaughter-house is located, shows offers lower values of dust pollution, offensive smells, which under certain atmospheric conditions are carried away over large distances, as far as the "23 August", "Viilor" and "Progresul" quarters, constitute an intense air pollution.

In the residential quarters lying far away from pollution sources atmospheric impurities oscillate around a figure of 10 grammes per sq.m per month.

Dust pollution fluctuates throughout the year on account of seasonal meteorological characteristics.

The values are the highest during spring and the lowest in winter.

As shown by analyses of the chemical composition, the sediments are composed of 70 per cent mineral substances while the rest consists of organic matter. In green open-air spaces the proportion of organic matter was found to attain 50 per cent.

Since air pollution in the city is not due to dust alone, but to noxious gases as well, numerous measurements of the concentration of SO_2, an important factor in urban air pollution, were carried out. The analyses carried out by the Institute of Hygiene have shown that the air of Bucharest is less polluted with SO_2 than with dust.

The zones showing the highest values of SO_2 pollution lie around the North Railway Station, the railway workshops and the locomotive depots where pollution values much higher than the admissible limits were recorded.

In the residential quarter around the North Railway Station the daily concentration of SO_2 was higher than the average admissible norm while in the Giulești district the concentration in a number of streets was twice as high as the admissible limit.

Around the East Railway Station, where a number of chemical works are located, SO_2 concentrations were also high. In the other industrial zones of the city served by railways and stations, the same phenomena were met with.

Around the Vulcan Factory and in the industrial zone along the Filaret-North Station railway line, high SO_2 concentrations were also recorded.

If the values obtained for SO_2 concentrations are compared with the minimum level of monthly pollution, namely that of $0{\cdot}10 mg/m^3$ it can be seen that this level has been considerably exceeded, especially in the North Railway Station zone.

The SO_2 concentration fluctuates considerably during the year in accordance with the meteorological conditions. These seasonal oscillations are characterized by maxima in autumm and winter and minima in summer.

It is especially important to learn about urban air pollution with a view to preventing the creation of conditions that are noxious to the human health.

Researches undertaken by experts in several countries reveal that in intensely polluted zones the morbidity and mortality rates caused by respiratory diseases are extremely high.

As shown by the statistics, cases of pulmonary cancer are increasing in the impure environments of large cities. These data confirm that air pollution is to be taken into account in the case of a large number of diseases of the respiratory organs.

The impure atmosphere of Bucharest with the pollution caused by industrial enterprises and by certain means of traffic has a significant influence on the health of the population. Studies carried out in certain polluted zones demonstrated a correlation between air pollution and the frequency of the cases of respiratory diseases.

To clean up the atmosphere of Bucharest, a series of actions are to be undertaken such as widening the extent of green open-air spaces; transferring certain factories and the slaughter-house outside the city; setting up filtering facilities for the industrial plants that cannot be transferred; providing for the trapping of released gases and the construction of level crossings at major traffic intersections. In addition, efficient measures ought to be taken to ensure that the smoke produced by the incinerators of the large blocks of flats should be released at the proper height. Means should also be found to trap the smoke resulting from combustion.

A task that cannot be dispensed with is the detailed study of air circulation at low and high levels. From such a study further essential corrections to economic building projects can be made to provide facilities for the protection of the city against air pollution (smoke, dust etc.).

AIR POLLUTION AND THE URBAN CLIMATE OF BUDAPEST

by

F. PROBÁLD

Nearly 20 per cent of Hungary's population is living in the capital. Even this territorial concentration of the population is surpassed by the agglomeration of industry: on the basis of employment in 1930 the share of Hungarian industry in Budapest was about 60 per cent and even now despite the process of decentralization during the last decades its share still amounts to 37 per cent. This industrial concentration, a product of history and of the favourable economic-geographical situation of the capital, has created numerous problems. One of them is air pollution.

Within the framework of the National Institute for Public Health and of the Centre for Public Health and Epidemiology systematic air pollution measurements have been carried out since 1958 at several points in the capital. As a result an overall picture of the degree of air pollution, its territorial distribution and its relationship to meteorological factors can be made.

From the health point of view the most significant is sulphur dioxide, which is rightfully considered an indicator of urban air pollution. In the winter half of the year the average sulphur dioxide content of the air exceeds 0·4 mg/m^3 in the major part of Budapest, while in the inner city and in the industrial territory of Csepel even 1·4 mg/m^3 has been attained. In the summer half of the year sulphur dioxide pollution is by about 40 per cent less, but compared with other cities, the values are still very high. The serious sulphur dioxide pollution, which can often be smelt, may be explained by the fact that the brown coal used in Budapest for industrial, traffic and heating purposes contains 2·0—4·5 per cent and the fuel oil 1·0—2·8 per cent of sulphur respectively. During the sixties about 260,000 tons of sulphur dioxide were released into the air of the capital annually. Lately, however, a marked decrease of the emission has been achieved, resulting in an improvement of the ambient air quality.

No such detailed data exist on the territorial distribution of smoke as on sulphur dioxide, but the result of systematic measurements at 11 rather polluted points in the city (annual average values of 1·11 mg/m^3) shows that smoke pollution also exceeds the tolerance level. During the heating season the smoke content of the air is 80 per cent greater than in the summer. The outdated methods of household heating, the obsolete heating installations of numerous industrial plants, the smoke from the railway stations and the diesel engines of motor traffic likewise contribute to air pollution.

Compared with smoke and sulphur dioxide, other pollutants are less important. The territorial average of deposited pollutants is relatively low (171 tons per sq.km per annum). Chloride and chlorine pollution is only considerable in the vicinity of certain industrial works. Carbon monoxide exceeds at peak hours the tolerance limit in some main roads of the city. The amount of hydrocarbons and nitrogen oxide originating from motor traffic keeps rapidly increasing, and despite the smaller number of cars, the downtown concentration of these pollutants falls no longer short of the level observed in large western European and American cities.

The seasonal variations in pollution already show the close correlation between air pollution and meteorological factors. Not only are more pollutants entering the air in winter, but the weather at that time also favours the accumulation of pollutants. The highest pollution level can be observed during weak laminar air-currents which blow frequently in winter from the SE sector. Under such conditions pollutants emitted by the industrial works and residential quarters bordering the capital on the East and South accumulate in the foreland of the Buda Hills. The frequent temperature inversion in the winter half of the year also lends itself to the process, and to the formation of smog from time to time.

The way in which the urban mezoclimate develops from the interaction of polluted atmosphere and built-up urban area is particularly interesting from the geographical aspect. By elaborating on the observations of the Institute for Meteorology supplemented by our own measurements it has been possible to investigate the difference between each of the components of the energy balance of the inner city surface of Budapest, and the corresponding data for a natural surface. The investigation revealed the physical (energy balance) bases of the formation of the urban climate, and above all of the urban heat island (Table I). The urban surface transmits during the whole of the year considerably more heat to the air than a natural surface. This surplus arises in winter mainly from urban energy sources (heating for industry, traffic and domestic heating purposes), and in summer from the fact that evaporation absorbs less heat from the surface. It can be calculated for the densely built-up part of the city, an area of 6 km in diameter, assuming a mean wind velocity of 3 m/sec, that the air of the city is exchanged 16,000 times per annum. Thus the surplus urban heat suffices to maintain a 100—120 m high heat island 0·9 °C warmer than the surrounding environment.

Hereafter those components of the energy balance will be dealt with in detail for which urban air pollution causes considerable changes in value.

The decrease in *direct radiation* to the town can be accounted for by a reduction in insolation and an increase in the turbidity factor. The mean value of the Linke turbidity factor on the SE side of Budapest, in Pestlőrinc is also very high (4·24). On December 1st 1965, on our crosstown trip with a Michelson-Marten actinometer, in the clean air of the western part of the city a turbidity factor of 3·03 has been observed. At the same time a value of 3·07 was obtained in Pestlőrinc and 4·10 in the inner city.

Global radiation has been registered on the Robitzsch pyranograph at 4 points in the city. Kitaibel Street on the western bank of the Danube in the heart of the urban area received on average between 1961–64 15 per cent less energy than nearby Szabadság Hill sited 350 m higher. The annual radiation loss at the urban station was only 12 per cent in 1937–39 which reflects the effect of increasing air pollution. But the considerable radiation

Table I

Deviations between the energy balance of the urban surface and a natural surface (kcal/cm²)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year (average)
A	—0·4	—0·7	—1·6	—1·0	—0·8	0·2	—0·2	—0·2	0·0	—0·9	—1·1	—0·6	—7·3
B	0·3	0·5	1·6	2·0	2·7	3·1	4·1	3·2	2·2	1·3	0·7	0·3	22·0
C	3·7	3·4	3·1	2·3	2·0	2·0	2·0	2·0	2·0	2·4	3·2	3·6	31·7
D	3·6	3·2	3·1	3·3	3·9	5·3	5·9	5·0	4·2	2·8	2·8	3·3	46·4

A = difference in net radiation;
B = in latent heat transfer by evaporation;
C = heat originating from urban energy sources;
D = difference in heat transferred to the air.

Table II

Average values of global radiation for the city (A) and its environment (B) (kcal/cm²); and the deviation (C) expressed as a percentage of B (1955—1968)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year (average)
A	2·0	3·4	7·0	10·2	13·2	14·4	14·8	12·9	9·7	5·8	2·0	1·6	97·0
B	2·7	4·3	7·9	11·3	14·2	15·2	15·5	13·6	9·9	6·5	2·7	2·0	105·8
C	25·7	21·0	11·9	10·1	7·0	5·5	4·1	4·8	2·4	11·7	25·0	20·3	8·8

loss at the urban station can be explained to a significant extent by the difference of altitude. The 14 years of parallel data series for the urban observatory and that at Pestlőrinc on the southeast side of the city, after considering the pollution effect of northwesterlies on the latter, allow an estimation of the loss in global radiation due to urban air pollution (Table II).

The radiation loss from the city is therefore very considerable, especially in the winter half of the year, when radiation is low in any case. It can be established, that the mean UV radiation loss of the inner city compared with Pestlőrinc amounts to 9·5 per cent. During the three winter months this rises to 26 per cent, which is even more substantial than the deficit of global radiation. These figures are based on the 1965–66 measurements of the Institute of Meteorology.

It is interesting that, although the city is in a more disadvatageous situation as regards incoming short-wave radiation, the albedo of the urban surface measured by means of model experiment, being smaller during almost the whole year, entirely outweighs this drawback. Thus in the amount of radiation absorbed, there is no substantial deviation between the urban and natural surface.

It is known that many authors attribute great importance to the greenhouse effect in the formation of urban climates; that is to the fact that the aerosols polluting the urban atmosphere augment incoming long-wave radiation. The long-wave radiation data series for Pestlőrinc and Kecskemét covering four years, determined by a Schultze balance meter have allowed conclusions to be drawn concerning the extent of this effect. When the wind is blowing from the NW sector, Pestlőrinc comes under the effect of the urban environment. In Kecskemét, on the contrary, air pollution is inconsiderable with either wind direction. During the course of our work the incoming long-wave radiation data for 12,000 intervals of one hour during the winter season have been grouped according to wind direction observed at Pestlőrinc and similarly for 525 such hourly intervals when the weather was entirely clear at both places. The mean value of incoming long-wave radiation showed good agreement in both the urban and the non-urban wind direction groups at both stations. Consequently the influence of the greenhouse effect on energy circulation may be very slight only. According to our calculations the surplus of incoming long-wave radiation does not attain 1 per cent even during the heating season. The urban surface is warmer than its surroundings and net long wave radiation therefore signifies a greater energy loss from it than from a natural surface.

Air pollution determines both directly, and indirectly through its climatic effects, the extent to which different parts of the city are able to ensure a favourable environment for man, and the extent they are suitable for a residential function.

The climatic environment often influences through economic factors the functional structure of cities. It is known that in London and Paris, for instance, the western, windward, quarters represent higher land values than the eastern areas with more polluted air. The situation is the same in Budapest. That part of the city with the cleanest air is sited to the west of the Danube on the Buda Hills, where villa-like residential development is general.

Moreover, according to the population census of 1960, the proportion of white-collar workers living in better financial circumstances surpasses 40 per cent of the population in this area. East of the Danube only in a small part of the downtown area does such a high concentration occur.

Building-site prices in Budapest are influenced by many factors and their territorial distribution is therefore very irregular. The influence of the climatic factor can be analysed by statistical methods, however; 45 sub-areas at a distance of 1—10 km from the city centre were investigated. Distance in km from the city centre (X_1) and the average sulphur dioxide concentration in mg per 10 cu.m in the winter half of the year (X_2) as an indicator of the climatic environment were taken as independent variables. The dependent variable (Y) is the basic land value expressed in Ft per 0·36 sq.m. (The basic land value stems from the average market price after having subtracted the value of area investments.) After determining the statistical correlation between the variables by multiple regression analysis, the following equation was obtained:

$$Y = 43{\cdot}79 - 23{\cdot}66 \log X_1 - 0{\cdot}69\, X_2$$

The correlation is significant at the 0·1 per cent level as shown by the F-test. The partial regression coefficient $b_1 = 23{\cdot}66$ is — according to the t-test — significant at the 0·1 per cent level; $b_2 = 0{\cdot}69$, on the other hand, was not significant. Thus the effect of air pollution and climatic conditions on land value has been verified from the available data at the 84 per cent level of confidence only. A difference of at most 22 Ft sq.m can be attributed to the effect of climate on land values taking into account the maximum territorial differences of sulphur dioxide concentration of the air in the city. This is equal to the total basic land value of the more remote parts of the capital.

Although to a certain extent the city structure accomodates itself spontaneously to the established atmospheric environment, well-considered and systematically realized measures are needed to reduce air pollution in Budapest. In 1959 the City Council passed a decree concerning air pollution control and this was followed by various measures leading towards a nationwide air quality regulation by the early seventies.

One important method of air pollution control, especially smoke pollution, consists of gradually introducing up-to-date heating techniques. By 1970 gas heating had been installed in 11·7 per cent and heating from central plants in 7·9 per cent of the dwellings. In 1975 these proportions will rise to 22·2 per cent and 17·0 per cent, respectively, i.e. in two fifth of dwellings up-to-date heating methods will exist. It is particularly favourable that gas heating is being firstly installed in the inner city where the air is extraordinarily polluted.

Relying on increased production from the recently prospected Hungarian natural gas fields, not only households but also the energy requirements of industry are to an ever growing extent satisfied by gas. This is the only viable way to reduce the sulphur dioxide content of the air. In 1965 10 per cent of the energy demand of the capital was satisfied by gas, rising to 32 per cent by 1970 and to 60 per cent according plans for 1980. Table III illustrates the changing balance of the various sources of energy used in the capital:

TABLE III

The energy requirements of Budapest according to different fuel sources (10^{12} kcal)

Year	Gas	Liquid fuel	Coke	Wood	Coal and briquettes	Total
1965	3·40	6·92	1·46	0·97	21·25	34·00
1980	27·0	12·00	1·66	0·97	3·37	45·00

It is to be expected that the present very heavy air pollution originating from industry and household heating will considerably decrease in the next few decades. But since private motorcars in Budapest will probably number over 100,000 by 1975, the fight against traffic-caused air pollution should also be taken up.

THERMAL INVERSION AND INDUSTRIAL POLLUTION OF THE NEAR-SURFACE AIR OF SOME DEPRESSIONS IN BULGARIA

by

H. TICHKOV

The Central and Rila-Rhodope regions, covering some 72 per cent of the area of Bulgaria, have proved to be favourable sites for the development of stable relief-dependent inversions both near the surface and at high altitudes. In addition to the positive landforms of Bulgaria's mountain ranges, these regions also include well-defined and deep negative forms which offer the best conditions for thermal inversions.

The Stara Planina System. This morphological unit comprises two subregions: the Main Range of the Stara Planina (the Balkans) and the Pre-Balkans.

The Pre-Balkans are of greatest importance in generating inversion conditions. Occupying an area of 14,500 sq.km or so and rising to a mean altitude of 364 m, this is a hilly country (200 to 600 m) for the most part, where individual slopes surround negative landforms of considerable extent, namely depressions, river valleys and valley widenings. It is here and on the lowlands of Belogradchik, Vratza, Botevgrade, Teteven, Sevlievo and Elena forming the morphological boundary between the Pre-Balkans and the Balkans proper that the most representative surface and high altitude thermal inversions in Bulgaria occur. In most of these depressions considerable populations and industries of national significance are concentrated.

Transitional mountain region. This comprises the central districts of Bulgaria. From the point of view of thermal inversion generation, however, the western (Kraishte-Ikhtiman) and the northern (Sredna Gora and Sub-Balkans) subregions are most typical. They display a true mosaic of high peaks and intramontane depressions varying in altitude from 2,285 m at Vitosha to 550 m on the Sofia Plain. 82 per cent of the western subregion belongs to the high mountain zone, and has a mean altitude of 802 m, while 60 per cent of the northern subregion comprises highland averaging 495 m above sea level. The two subregions include a system of deep and closed negative forms all lower than 1,000 m in altitude. Because of the presence of various kinds of mineral resources, available labour and other favourable conditions, a considerable part of the Nation's industry has been developed in many of these depressions, despite the fact that thermal inversions are most intensive and lasting there.

The Rila-Rhodope Massif. Three principal mountain groups trend in an east-west direction: the Ossogovo-Belassitza, the Rila-Pirene and the Rhodope separated from one another by deep grabens forming the valleys of the Strouma and Mesta rivers. The mountain groups are imposing and monolithic, while the river valleys separating them represent a series of orographically subsided plains, where dynamic thermal inversions are generated.

Negative landforms are poorly distributed both in the Rhodope Massif itself and in the rest of the mountain region. Hence the scarcity of local thermal inversions.

Very powerful and stable thermal inversions of dynamic origin occur on the Thracian High Plain and in NW Bulgaria. Barred by the mountains, the warm air flow at high altitudes cannot oust the excessively cool air masses resting on the plains to the north of the mountains. Consequently, a stable vertical air stratification with all the resulting consequences develops.

It is the pollution of the inversion layer by solid particles and gases of industrial origin that is most significant. This pollution attains its highest intensity above the intramontane plains, where, on account of thermal inversions the stratification of the near-surface air layer is most stable.

Investigations concerning the distribution, stability and vertical extent of thermal inversions in Bulgaria have shown that they occur most frequently over the cities of Vratza, Botevgrade, Sevlievo, Sofia, Pernik and Ikhtiman. All these settlements are situated amongst orographically well-defined negative landforms and are densely populated and dotted with air-polluting industrial plants.

In general, the frequency of thermal inversions is higher during the cooler half of the year. As shown by aerial survey and by the profile of the vertical stratification of the atmosphere above certain parts of the country, the period from October to March is characterized by a variable number of thermal inversion days, the frequency of which was found to be inversely proportional to the thickness of the inversion layer (Table I).*

Atmospheric soundings above Sofia (Blaskova *et al.*, 1968) have shown that the mean thickness of the inversion layer varies between 350 and 600 m from month to month. It attains its highest value, 550 m, in winter, and lowest in summer, 380 m. The inversion layer above Sofia can attain a maximum

TABLE I

Average number of thermal inversion days

Locality \ Month	X	XI	XII	I	II	III
Sofia	17·3	17·5	19·0	16·5	13·2	10·7
Pernik	19·5	15·8	15·0	15·2	9·8	12·5
St. Dimitrov	15·8	11·8	13·9	13·4	12·0	10·8
Kazanlik	3·5	4·1	4·8	4·0	1·8	0·3
Botevgrade	0·3	0·7	7·0	4·6	1·8	0·2
Varshets	0·9	3·1	7·2	4·9	3·3	0·4
Sevlievo	19·2	14·6	18·1	18·3	15·6	14·1

* The low average number of thermal inversion days at Kazanlik, Botevgrade, Vratza, and Varshetz is explained by the inversion layer being only 600 m in thickness compared with 1,000 to 1,200 m at other places.

thickness of 2,300 m, although the highest frequency, 65 per cent of occasions pertains to a thickness of 100—150 m.

In the Pre-Balkans the same situation can be observed. As evidenced by investigations of the vertical stratification of the atmosphere up to an altitude of 2,000 m, the highest frequency, 40 to 60 per cent of inversions approximate 1,500 m in thickness.

Investigations of the stability of inversions indicate that some vanish during the day, while others only temporarily disappear, usually at noon, increasing the altitude of the lower boundary of the inversion layer. Others can last a whole day or remain unchanged for several days. All in all, it is in winter that inversions attain their highest stability.

Above Sofia inversions of more than 40 m in thickness are most frequent among those lasting for 11 to 12 hours. About 20 per cent of the cases are characterized by a duration of one day and only 7 per cent last longer than two days. In rare cases, such inversions above Sofia may last for 5 to 7 days (Blaskova *et al.*, 1968).

The most substantial air pollution, however, takes place in very thick inversion layers of comparatively high stability. Above Sofia, inversion layers up to 1,000 m in thickness are usually of one-day duration.

In the Pre-Balkans, in the vicinity of the city of Sevlievo, inversions of 1 to 3 days average duration and a thickness of 100 m show the greatest frequency (Tichkov 1973). Inversions of 200 m thickness also occur, rather frequently (Table II).

TABLE II

The frequency of inversions at Sevlievo in terms of the duration and thickness of the inversion layer (in per cent)

Duration (day) / Thickness of inversion layer (in m)	1—3	3—5	5—7	7—10	10 and >10
	O C T O B E R				
103	51·0	18·3	14·3	0·2	8·2
195	75·0	14·4	0·0	8·9	1·7
328	65·9	18·2	6·8	6·8	2·3
1,503	0·0	0·0	0·0	0·0	0·0
	J A N U A R Y				
103	57·7	17·3	9·6	7·7	7·7
195	55·0	23.3	3·6	12·6	5·5
328	45·6	22·8	13·2	15·1	3·3
1,503	75·7	16·2	8·1	0·0	0·0

In stable conditions, an inversion may be prolonged for 10 or more days, but according to Table 11 such an inversion layer attains a maximum thickness of 300 to 350 m.

Under conditions of thermal inversion there is a direct relationship between the layer of the atmosphere that is polluted with aerosols on the one hand, and the sign of the vertical thermal gradient from the lower to the upper boundary of the inversion layers on the other.

As evidenced by studies of inversions above Sofia (Blaskova *et al.*, 1968), positive vertical thermal gradients are 7 times more frequent than in other cases. All year round, the average vertical thermal gradient within the height interval 0 to 300 m is 0·6 to 0·8 °C per 100 m. In the months of April and August it is as low as 0·1 to 0·2 °C.

In the region of the Pre-Balkans in winter the difference in 5-day air temperature averages between the lower and upper boundaries of the inversion layer is most frequently 0·1 to 3·0 °C, less frequently, 3·1 to 5·0 °C and, least frequently, above 5·0 °C (Tichkov, 1963).

It is evident from these characteristics of inversions, that the stable vertical stratification of the air layer above the negative landforms of the western part of the transitional mountain region and above the Pre-Balkans ensures conditions "favourable" for the accumulation of air pollution of industrial origin.

Unfortunately, on the intramontane plains the location of the cities of Sofia and Pernik, the main industrial centres of Bulgaria, the sources of industrial air pollution are abundant. In the neighbourhood of Sofia alone with a population of 1 million inhabitants, there are 700 industrial plants of which 325 actively pollute the air. Among these are thermal power plants with a total output of 220,000 kW, metallurgical works with an annual output of 3·5 million tons of pig iron, steel and rolled-ware as well as mechanical engineering and chemical enterprises. Further, the capital lacks a unified communal heating system so that a considerable part of the pollution derives from domestic sources. The contribution of the continuous increase in the number of motor vehicles cannot be neglected either.

A similar situation exists at the city of Pernik, with a population of 80 thousand inhabitants which is the location of a metallurgical factory, thermal power plants of 160,000 KW capacity, a cement factory and a series of other air-polluting enterprises. A great part of the pollution derives from the combustion of coal, the Pernik coal field being one of the largest in the Nation.

The concentration of the different air-polluting agents over Sofia correlates highly with the regime of thermal inversions. According to the studies of a team of Bulgarian scientists (Blaskova *et al.*, 1968), SO_2 pollution of between 1·048 and 1·189 mg/m^3 above Sofia lasts on average for more than two days during thermal inversions. In isolated cases, concentrations of 1·5 to 1·7 mg/m^3, which is thrice the admissible norm of 0·5 mg/m^3, can be observed.

In analyzing the synoptic situations of anomalously high SO_2 concentrations (above 0·5 mg/m^3), one can see that it is anticyclones, coupled with high atmospheric pressure fields, that account for 70 per cent of all cases. Moreover, during stable conditions the lower boundary of the inversion layer only rises temporarily to 1,500 m above ground surface at noon, so that 50 per cent of the high SO_2 concentrations correspond to thermal inversions that disappear around noon.

The influence of the thickness of the inversion layer on the concentration of SO_2 is readily shown by the fact that in Dragalevtzi village, lying 100 m higher than Sofia, the most frequently measured (50 per cent of the time) winter concentration is 0·0 to 0·2 mg/m^3, compared with 0·6 to 0·8 mg/m^3 in 30 to 35 per cent of instances in Sofia. In summer, however, on account of better near-surface air exchange the SO_2 concentration above Sofia and Dragalevtzi averages 0·0 to 0·2 mg/m^3.

The results obtained for the correlation between the duration of thermal inversions and the concentration of SO_2, show that in Sofia the highest concentrations (2·2 and even 2·6 mg/m^3) occur in general on either the second or third day after the beginning of an inversion.

A good correlation exists between both the vertical thermal gradient and the thickness of the inversion layer on the one hand, concentration of SO_2 on the other (Blaskova *et al.*, 1968).

As for the concentration of non-toxic air-pollutants such as soot and other solid particles, the regularities observed are the same as for air pollution with toxic aerosols.

As evidenced by measurements of the non-toxic dust content of Sofia's atmosphere during the 3 years 1967—1969, air pollution is characterized by a definite seasonal regime, which depends in great measure on the general weather situation during a given season and the predominant synoptic situation.

On the basis of the admissible limits established by Burnstein (1953) for cities, measurements prove that the concentration of non-toxic dust in the air of Sofia during the winter months exceeds the limits of tolerance.

In these cases inversions are again one of the factors directly influencing the rise in pollution. During inversions of crucial importance is the degree of vertical stability, the extent of horizontal air movement and the presence of condensed air vapour.

Investigations prove that the highest degree of air pollution is observable when wind velocity is between 0·0 and 1·5 m/s (low source of pollution) and 4·1 to 6·0 m/s (high source of pollution). In the presence of fog air pollution was found (Teneva and Manolov 1968) to be 3·64 times higher on average than during the absence of fog.

The direct relationship existing between the degree of non-toxic air pollution and the presence of industrial sources of pollution is evidenced by the weekly regime in pollution. The average daily values of total air pollution vary between $0{\cdot}082\times10^{-3}$ g/m^3 and $0{\cdot}103\times10^{-3}$ g/m^3 during the week, the lowest values occurring, as a rule, on Sundays, and the highest on Fridays. In autumn (the second season in terms of pollution) highest values occur on Thursdays and lowest on Sundays. During spring, the maximum is on Fridays and the minimum on Sundays, while during summer when pollution as a rule is lowest, the maximum figures are observed on Wednesdays ($0{\cdot}081\times10^{-3}$ g/m^3) and the minimum, $0{\cdot}063\times10^{-3}$ g/m^3 again on Sundays.

CONCLUSIONS

The wide distribution of negative landforms that is one of the prerequisites for the formation of thermal inversions of medium thickness (300—500 m) is a cause of air pollution with toxic and non-toxic foreign particles. Another cause is the presence of pollutants of industrial origin, because for economic reasons, industrial plants are mainly built in large cities and on negative landforms irrespective of the pre-existing unfavourable climatic conditions.

To prevent future air pollution, the following principles should be respected:

(a) the most efficient means have to be used to reduce industrial emission into the air to the lowest possible levels;

(b) the construction of industrial plants should not be permitted until local climatic features have been carefully studied.

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IV. SOME SPECIAL ASPECTS OF THE INTERRELATIONSHIP BETWEEN MAN AND THE ENVIRONMENT

RECREATION AND THE ENVIRONMENT

by

V. S. PREOBRAZHENSKY, Y. A. VEDENIN and A. V. ANTIPOVA

The use of leisure time in modern society is becoming a most important social problem. In this connection there emerge a number of new social, technical and scientific questions, which have not yet been satisfactorily solved. A special place is occupied by the relationship between the recreational activities of the population and the natural environment.

SOCIAL FUNCTIONS OF LEISURE TIME AND THE ENVIRONMENT

Qualitative and quantitative indices of leisure time are determined by the level of socio-economic development of society. K. Marx wrote that in future "the measure of richness will not be working time, but leisure time". He was the first to point out the heterogeneity of leisure-time functions.

Soviet sociologists single out two main functions of leisure time: "that of restoring man's strength for labour and other obligatory occupations, and spiritual activities (cultural, ideological and aesthetic) and that of the physical development of man "adding that "... in modern society the second function is gradually acquiring greater importance ...".

Soviet society is interested in the high intellectual attainment of its citizens and in their harmonious development as individuals. That is why it strives to guide their development, and to encourage their interests in events and phenomena that improve their creative abilities. Thus, in the organization of recreational activities in the socialist society, the function of an individual's physical and spiritual development aquires primary importance.

This is illustrated by current practice in Soviet society, in which "the right to rest" is not only secured in the USSR Constitution, but active measures are being taken aimed at the development of mass educational and sport tourism by encouraging excursions, including local tourism and excursions to resorts, children's mass tourism, education and tutoring, and the study of nature and local history.

Recreational activities are taking place against a background of global urbanization and increase in population mobility.

Continuous mass contacts, vast flows of information and noise, high living standards with physical passiveness and life in an artificial, monotonous environment isolated from nature are the specific features of the modern way of life of a large city dweller. These features have conditioned his attraction to nature, especially during leisure time. The increase in general population mobility is due primarily to leisure pursuits.

SPECIFIC FEATURES OF MODERN RECREATION ACTIVITIES

As a result of the factors mentioned above the following tendencies develop:

(1) an increase in the differentiation and integration of recreational activities;

(2) an increase in the role of mobile types of activity.

The growth in leisure time and, first of all, the length of the week-end and vacations in combination with an increase in cultural level and opportunities for satisfying the needs of individuals has resulted in the differentiation and integration of recreational activities. We are witnesses to a rapid growth in the variety of recreational activities and to the formation of new combinations (during single days and whole vacations). Priority is given to activities associated with educational processes and the development of man as an individual, as well as to activities connected with the use of natural and cultural values.

Simultaneously with this process of differentiation an integration of activities also develops. When on vacation a person tries to satisfy a maximum of his various needs and the necessity arises to include in the system of vacation activities those that belong to quite different groups — physical and amateur pursuits, the use of cultural and natural values. Each group of activities compliments the other and taken together comprise a single whole.

The second most important tendency is an increase in the role of mobile activities, for instance amateur sports, travel etc.

The increase in the number of recreation activities and the growth in importance of mobile pursuits leads to a sharp extension of land areas needed to meet recreational requirements.

THE PRINCIPAL ELEMENTS OF A SPATIAL RECREATIONAL SYSTEM

The meeting of recreational demands goes on within a multicomponent spatial system, in which numerous elements, for instance people with natural and cultural spatial complexes, technical systems and service personnel are united. In this connection the hypothesis is put forward of a complex controllable and partially self-regulating spatial system. The principal element of a spatial recreational system is the subsystem of a "group of holiday-makers". The very development and the functioning of the system as a whole is conditioned by the needs of people to perform some types of activity. The connection of holiday-makers with natural and cultural spatial complexes and with engineering works and service personnel is a realization of this need.

In the study of a recreational system great importance is attached to the geographical aspects. The system is conditioned by geographical selectivity of recreational activities by people, by the heterogeneity of natural complexes and their different stability under recreational impact, and by the interaction of these systems with spatial-production complexes (which are related to recreational systems either as regions of demand, or as competing regions in the sphere of natural resource use).

A recreational system may and must be considered as an economic system as well, and all its characteristics must be converted into cost indices. Expenditure and income budgets must be substituted for the tim e budget of holiday makers and the exploitation characteristics of technical systems.

All the peculiarities of the formation of recreational needs are reflected in the contents of the recreational system and its subsystems.

The first of the subsystems, the holiday-makers, consists of various groups of people. The characteristics of this subsystem reflect the social and age structure, the national, the regional, and the psychological characteristics of certain groups of people and individuals. Relationships with other subsystems depend upon the demands of people and the choice of pursuits undertaken at leisure time.

The second subsystem consists of the natural and cultural and the spatial and aquatic complexes and is very important for the functioning of the system. The properties of the complexes must meet the individual recreational demands of holiday-makers, as well as the requirements of the organization of the recreational system as a whole.

The third subsystem, a technical complex, promotes the satisfaction of specific recreational demands, on the one hand, and provides satisfactory living conditions for holiday-makers and service personnel, on the other.

The fourth subsystem, a group of people offering services must do the following: on the one hand obtain, collect, preserve, and transport articles for the consumption of holiday-makers (natural products, information, cultural values) and, on the other hand, dispose of waste.

An important part of the system is management. It compares information obtained about the satisfaction of the needs of holiday-makers with information on the properties and capacity of natural complexes, the state of the technical system and service personnel. Only then does it make decisions on changing relationships between the subsystems.

THE SALIENT PROPERTIES OF SPATIAL RECREATIONAL SYSTEMS

Properties conditioning the character of SRS are the following: completeness, dynamism, stability, and reliability.

The study of these properties makes it possible to solve problems associated with the definition of the optimal variants of the functioning of SRS, opportunities for forecasting, and the elaboration of optimum spatial structures, etc.

Completeness supposes a presence of close interactions among the subsystems, when a change in any of the subsystems changes the state of the whole system. It calls for careful considerations of the attempts to introduce into any of the SRS elements.

Dynamism represents the process of the changing the functions of recreational areas.

As an example of such a process we may present a thirty-year history of the formation of the Moskva-Volga Canal. Areas that before 1960 have been visited mainly by fishermen and nature lovers, are now used on Sundays for mass excursions of the whole staff of organizations. The next stage in the process is the beginning of capital construction on the Canal banks with the organization of tourist camps and hostels.

At the present time there is a tendency for built-up territories around the expanses of water to merge as the desire of people to recreate near water is so great. In such instances, when the areas are being built on, the use of natural complexes by holiday-makers will be confined to bathing and their activities will mainly consist of visits to the cinema, concerts, sport events etc.

The *stability* of SRS functions is characterized throughout the range of recreational activities and is defined by the stability of separate subsystems within the SRS.

The stability of natural complexes is very important. It is closely associated with the definition of pressure standards for different natural complexes as well as for a general capacity of recreational areas and with the working out of their planning structure and functional zoning. To define an admissible pressure we must, first of all, select the ways of using natural complexes. We have to satisfy the needs of a continuously growing number of people by expanding the areas of SRS, thus reducing the pressure. In this case we very soon encounter great difficulties that logically lead to decisions such as to make all land and water a recreational foundation, to reduce and then to limit the growth in recreational demands by society, and to limit population growth.

In this connection it is worth considering the possibilities for intensive recreational development, thus creating cultural-natural complexes characterized by increased stability and the following structural changes: flows of holiday-makers are localized along certain lines of communication and in selected areas, a pressure limit is introduced for some areas, and the composition and structure of vegetation is thus improved.

To define the stability of SRS as a whole we must study not only the stability of natural complexes, but also that of the subsystems. For instance, the problem of studying the stability of engineering constructions is very important. However, building science considers the phenomenon of "stability" only in a physical sense. But it is important to understand the mechanism of "moral stability" as well, in other words the degree of fitness of engineering constructions in the context of the changing nature of requirements. Here we have an important practical problem and opportunities for using one construction or a complex of constructions to perform not only current, but also perspective functions.

Reliability. The study of demand has shown that the most popular areas are those guaranteeing a good rest. For instance, the reliability of the functioning of a SRS is to a great extent conditioned by the stability and invariability of climatic characteristics. So, while 24 per cent of holiday-makers vacate to the Black Sea, the Baltic Coast, where the weather is rather unstable, attracts only 5·6 per cent.

FUNCTIONAL TYPES OF SPATIAL RECREATIONAL SYSTEMS

As the SRS must satisfy the demands of different groups of people, it must be specialized. This specialization is expressed through the ability of holiday-makers to select their activities as regards the environment. Selectivity is defined as a specific connection between the subsystem of "a group of people" and other subsystems of the SRS.

The ability of holiday-makers to select the geographical environment depends, first of all, on the difference in recreational requirements among the various social-demographic groups of the population. These requirements can be satisfied only when certain characteristics in the rest of the SRS subsystems are present. On the other hand, selectivity is connected with the space heterogeneity of the properties of the natural environment, which is important when an appraisal of the natural provinces of the USSR for the purposes of recreation is carried out.

The differentiation and integration of recreational activities precondition a variety of forms for satisfying recreational needs and a close spatial and technological link exists between them. The variety of forms for satisfying recreational requirements leads to the development of numerous spatially divided monofunctional types of system, because of population mobility and the incompatibility of some recreational activities. Polyfunctional types of system will also become important.

Becoming more specific typologically, each recreation system acquires an increasing degree of individuality. The need to make every SRS unique is especially great today because holiday-makers engage in activities characterized by increasing mobility. Recreation becomes a mass product and all people strive to obtain equally comfortable conditions. Due to this, it is necessary to preserve the variety of the environment as the most important resource for recreation, to conserve little-changed natural complexes, to take into account local features in the architecture of new buildings, to preserve monuments of culture and history, and to maintain national craftsmanship.

With the increasing number of SRS types and requirements the individuality links among different SRS's become closer resulting in the formation of a network of recreational areas. This is conditioned by the process of integration in the sphere of recreational activities, which has already been considered above. The complete recreational demands of society cannot be met by separate institutions or even regions, but by a combination of recreational systems with specialized functions, united into a single network by transport communications and tourist routes. Within this network every holiday-maker must have the opportunity for free choice among the various territorial elements.

So the process of functional and spatial differentiation and integration of SRS's reflects those changes that take place in the sphere of recreational activities — the complication of demand, the increase in mobility of holiday-makers, and the striving of people to develop both physical and spiritual attributes.

THE SPECIAL ROLE OF MANAGEMENT

We have already pointed out that the SRS is a controlled system. It is through the management of SRS's and their network that we can solve the principal conflicting problems that arise while creating a service system, with the simultaneous conservation of nature. The management, control and direction of growth and development of recreational areas, is a complicated task. The complex nature of the latter depends on the fact that there are great numbers of people to be controlled who have different and constantly changing demands. Indeed, the functioning of the system itself is predetermined by the necessity to meet these demands. Thus, the orders of a managing body must be introduced in such a way that, if the opportunities do not exist to meet certain demands in one region, they should be satisfied in another region, provided it has similar characteristics. Limitations may be introduced either by educational means, or with the help of the functional zoning of areas within the overall system. Administrative limitations, directly concerning holidaymakers must be at a minimum. For instance, the visiting of protected zones in national parks is not primarily regulated by the banning of movement across them but by the absence of roads to reduce accessibility as hiking will be undertaken by only a small number of visitors. Convenient plots for fires and tents, the availability of specially provided fire-wood and reasonably chosen camping plots for motor transport create conditions for the controlled use of an area.

A monitoring system must be developed at all levels, beginning with state bodies, and embracing all SRS networks up to separate recreational institutions.

The system of management is especially important in the context of the organization of the most rational and multiple use of an area in combination with different types of usage. The same complexes may almost always be used for different types of activity. Many lands suitable for recreation already perform agricultural or forestry functions.

There are several ways of solving the problem of the interrelations among the different functions. The first way is the co-operative use of a territory. Lakes and water storage reservoirs may be taken as an example. They are usually used for industrial purposes and amateur fishing. The idea of the recreational use of industrial forests has widely spread throughout Europe.

The second way occurs when there are some types of recreational activity incompatible with other functions (for instance, sanatoria versus natural monuments). That is why there arises a problem of controlling demand through land regulation which afterwards reverts to recreational use.

There is no need to point out that recreational activities belong to those types of activity that are especially concerned with nature conservation, providing both favourable ecological characteristics in the environment and information diversity. This is preconditioned by the fact that nature conservation is one of the most important means of preserving the social function of recreational systems. By protecting the subsystem "natural complexes" we, at the same time, help to stabilize the whole system.

It is worth mentioning again that the management of nature conservation begins with a process of design and must be continuously carried out in constructing and using the SRS.

The regulation of recreational activities may be classified as one type of management that has the greatest information capacity. It must contain data on a mass of changing social, economic, geographical, medico-biological, technical, and organizational variables. Due to this, the management of the "recreation activities-environment" system is especially interested in the development of interdisciplinary and scientific-technical studies, united through a system approach and based on a profound knowledge of the objective laws of the development of society and nature.

The socialist economy with its universal principle of planning, its public ownership of lands, water, mineral resources, and forests provides great opportunities for the rational control of recreational systems on a more purposeful basis, taking into account the conservation of those natural objects and natural conditions that present the greatest value from the point of view of the utilization of a territory.

THE INFLUENCE OF THE GEOGRAPHICAL ENVIRONMENT ON THE LOCATION OF TOWNS IN AFRICA

by

B. DUMANOWSKI

The question of urban location is as old as the cities are themselves. It can be considered from the practical point of view by thinking over the choice of places for a town location or from the theoretical point of view by looking for regularities in the location of the already existing towns. In the theory of urban location one pays attention first of all to the influence of non-environmental factors. Apprehension at the imputation of geographical determinism or environmentalism, on the one hand, and the inadequateness of methods, on the other hand, have probably had their effect on the low level of interest in the analysis of the relationships between the location of towns and their environment. It is obvious that the environment does not determine the location of towns, but it does not mean that no relationships exist between the site of a town and its environment. Thus, at present a paradoxical situation is in being. On the one hand, there is some apprehension at the imputation of determinism in theoretical studies and on the other hand, a practical urban planning physiography is developing by performing detailed research on the environment that preceded the location of towns. One might think that it is only at present that some attention is being paid to the environment while in former times other conditions influenced urban location. Was this so? Sometime between 27 and 13 B. C. a book written by Marcus Vitruvius Pollio "De Architecture Libri Decem" appeared. This author stresses very much the necessity, as we would say now, of taking into consideration environmental conditions in the location of city walls, pattern of streets and even the site and architecture of particular buildings.

The small number of analytical studies of the relationships between the environment and the location of towns does not mean, however, a complete lack of interest in these problems. Most of the books within the field of urban geography draw attention to the fact that the site of urban places is also determined by the geographical environment. Nevertheless, in general very little place is devoted to it and the influence of non-environmental factors are described in more detail (Johnson, 1969).

In the publications most frequently dealing with the problem of the influence of environment upon the location of towns, correlations existing between elements or features of the environment and the location of towns are indicated. In this way S. A. Queen and L. F. Thomas (1939) consider the size and shape of land and water areas, surface, terrain, climate, water supply, water bodies and native vegetation as features of a simple site. Such authors describe rather than analyse the influence of the above mentioned environment attributes upon urban location. G. Taylor (1951) in his widely known publication reviews the influence of environment by analysing the relationships between its elements and urban location. From Taylor's work, however, we only learn which particular environmental features are conductive to urban location and are not made aware of the influence of the environment as a whole.

J. Denis (1958) makes a comparison between the location of towns in Central Africa and latitude as well as annual rainfall, temperature and height above the sea level. He does not find any correlation. Taylor, however, found a correlation between annual rainfall and distance between the cities in the USA. Investigations performed in other areas do not prove, however, the above correlation. Thus, one may conclude that there is no relationship at all.

Methods applied in the comparison of urban location with particular elements of the geographical environment are based on the hypothesis that there is a simple relationship between location and elements of the geographical environment. It seems that these relationships are far more complicated and the utilization of such methods will not produce the expected results. So, other ways must be found.

In 1968 the author dealt with the problem of the influence of the environment as a whole upon distribution and density of population in Africa. There it was assumed that the same environmental element when taken in conjunction with the others very often is favourable for the settlement of population in one area but unfavourable in another. For example water bodies induce the settlement of population in arid climates but on the contrary in humid areas they have quite the opposite effect. The same occurs with relief forms that depending upon the kind of climate have different influences upon the distribution of population.

A common feature of particular environmental elements that influence positively the distribution of population is a sudden change in their type. Those areas where great changeability of particular environmental features is marked, are usually favourable for the settlement of people. From the description of many urban locations quoted by G. Taylor the same conclusions can be drawn, and one such example is the towns lying along the Appalachian Fall-line in the USA. These towns are located along the border between granite and sedimentary rocks. On this border there is also a remarkable morphological step. A similar but smaller example can be found in Southern Ontario on the edge of the Pre-Cambrian shield. In the region of Reims, France, the location of cities corresponds to changes in relief and geological structure. From the observations of the author along Canadian rivers it is apparent that the most probable urban locations are where a large tributary enters the main river or where rapids appear on the river.

J. Denis (1958) thinks that cities come into existence where obstacles occur on transport routes, for example at water falls on rivers. A similar transport obstacle is a seashore or a lake coast. Therefore, in this case it is quite evident that change within the geographical environment takes place.

Bearing in mind the above observations the author set out to check whether similar relationships exist on the African continent.

In order to investigate the relationships between urban location and the geographical environment in Africa places in which the population surpasses

100,000 were chosen. These cities were designated on the basis of data taken from the U. N. "Demographic Yearbook" of 1968. Next, based on topographical, geological, soil and climatic maps urban locations were checked to see whether they agree with the differentiation of particular elements of the geographical environment. The differentiation was easily found on the map in the case of geological structure and soils. An important and easy dividing line to fix is a shore line since it separates sea and land environments. It is far more difficult to determine dividing lines within relief and even more so for climate. As far as relief is concerned, stepped-terrain was considered to produce areal disparities. It was, thus, the neighbourhood of mountain massives, more distinctive edges, bigger inselbergs etc. As climatically differentiated are places lying on the dividing line between the most frequently distinguished climate regions on the African continent. Such are the dividing lines between the Mediterranean and arid climates, the arid and savannah climates, the dry savannah and humid savannah climates as well as betveen the humid savannah and equatorial climates. These dividing lines generally coincide with the 200, 1000 and 1500 mm isohyets. Consequently, these three isohyets were considered the lines of greatest climatic differentiation. In this respect because of the lack of material concerning the differentiation of water systems such as rapids and fording places, it was only shown whether a given city is situated by a river or not. The differentiation of the vegetation cover as well as the fauna was completely omitted since no suitable material was available.

To examine accurately whether any correlation exists between urban location and the differentiation of the environment it is indispensable to have at one's disposal detailed material dealing with particular environmental elements. On the one hand, we should have detailed maps, but on the other hand, they should be of the same scale. Unfortunately, such materials were not available for the whole continent. Thus, the author was obliged to use very general maps that did have the advantage of being at identical scale of 1 : 5,000,000. In consequence, the degree of generalization of particular problems is more or less the same, and thanks to it the material is comparable.

As shown in Table I, only a few urban places are not located on rivers. But surprising is the relatively close correlation with change in geological structure. Here, we do not count mineral resources since they have not been taken into consideration. The above correlation probably results to a great extent from the fact that along the dividing line of geological formations water springs often appear.

The correlation between change in soils, climate and relief is more or less of the same degree and every fourth or fifth city is connected with change within these elements. The establishment of a hierarchy of particular environmental influences on the basis of the material presented would be risky because of its highly general nature. With more detailed material a different hierarchy could well be established.

On using more detailed maps the number of correlations with relief would increase because of the appearance of some smaller morphological forms. Similarly the number of rivers and geological and soil divides would increase as well. The number of coastal towns would not change. As far as climatic divides are concerned, their number results from the criteria being utilized

TABLE I

Cities with populations of 100,000 or more inhabitants and selected environmental features

No. City	Country	Population	Date	Land-sea border	River	Relief	Geol. struct.	Soil	Cli-mate	Number of correlations
1. Alger	Algeria	903,530	1966	+		+	+	+		4
2. Annaba	Algeria	152,006	1966	+	+	+				3
3. Constantine	Algeria	243,558	1966		+	+	+			3
4. Oran	Algeria	327,493	1966	+		+	+			3
5. Luanda	Angola	(224,540)*	1960	+						1
6. Douala	Cameroon	(200,000)	1965	+	+		+	+		4
7 Yaounde	Cameroon	101,000	1965							—
8. Bangui	Centr. Afr. Rep.	(150,000)	1966		+		+	+	+	4
9. Brazzaville	Congo (Brazz.)	(136,200)	1962		+		+		+	3
10. Jadotville	Congo (Kinsh.)	102,187	1966							—
11. Kinshasa	Congo (Kinsh.)	901,520	1967		+		+		+	3
12. Kisangani	Congo (Kinsh.)	149,887	1966		+		+	+		3
13. Lubumbashi	Congo (Kinsh.)	233,145	1966		+					1
14. Luluabourg	Congo (Kinsh.)	140,897	1966				+		+	2
15. Cotonou	Dahomey	111,100	1965	+						1
16. Addis Ababa	Ethiopia	644,120	1967		+	+		+		3
17. Asmara	Ethiopia	190,500	1968			+	+			2
18. Accra	Ghana	615,800	1968	+				+	+	3
19. Kumasi	Ghana	281,600	1968				+		+	2
20. Sekondi-Takoradi	Ghana	128,200	1968	+			+		+	3
21. Conakry	Guinea	(197,267)	1967	+					+	2
22. Abidjan	Ivory Coast	(282,000)	1964	+				+		2
23. Mombasa	Kenya	(234,000)	1968	+	+		+			3
24. Nairobi	Kenya	(479,000)	1968					+		1
25. Benghazi	Libya	137,295	1964	+			+		+	3
26. Tripoli	Libya	247,365	1968	+					+	2
27. Tananarive	Madagaskar	335,149	1966		+		+	+	+	4
28. Blantyre-Limbe	Malawi	109,461	1966			+	+			2
29. Bamako	Mali	(175,000)	1967		+				+	2
30. Casablanca	Marocco	1,250,000	1968	+			+			2
31. Fés	Marocco	270,000	1968		+	+	+			3
32. Kénitra	Marocco	120,000	1968		+			+		2

33. Marrakech	Morocco	285,000	1968		+	+				2
34. Meknés	Morocco	225,000	1968		+	+	+			3
35. Oujda	Morocco	140,000	1968				+	+		2
36. Rabat-Sale	Morocco	410,000	1968	+	+		+			3
37. Safi	Morocco	120,000	1968	+			+			2
38. Tanger	Morocco	150,000	1968	+						1
39. Tétouan	Marocco	115,000	1968		+	+	+			3
40. Lourenço-Marques	Mozambique	(178,546)	1960	+	+					2
41. Aba	Nigeria	131,003	1963		+					1
42. Abeokuta	Nigeria	187,292	1963		+		+			2
43. Ado	Nigeria	157,519	1963							—
44. Benin	Nigeria	100,694	1963		+					1
45. Ede	Nigeria	134,550	1963		+				+	2
46. Enugu	Nigeria	138,457	1963		+	+		+		3
47. Ibadan	Nigeria	627,379	1963		+	+			+	3
48. Ife	Nigeria	130,050	1963		+				+	2
49. Ikere	Nigeria	107,216	1963							—
50. Illa	Nigeria	114,688	1963		+	+			+	3
51. Ilesha	Nigeria	165,822	1963			+				1
52. Ilorin	Nigeria	208,546	1963		+					1
53. Iwo	Nigeria	158,583	1963						+	1
54. Kaduna	Nigeria	149,910	1963		+	+				2
55. Kano	Nigeria	295,432	1963		+	+				2
56. Lagos	Nigeria	665,246	1963	+	+				+	3
57. Maiduguri	Nigeria	139,965	1963		+			+		2
58. Mushin	Nigeria	145,976	1963					+	+	2
59. Ogbomosho	Nigeria	319,881	1963							—
60. Onitsha	Nigeria	163,032	1963		+			+		2
61. Oshogbo	Nigeria	208,966	1963		+				+	2
62. Oyo	Nigeria	112,349	1963							—
63. Port Harcourt	Nigeria	179,563	1963	+	+			+		3
64. Zaria	Nigeria	166,170	1963		+					1
65. Dakar	Senegal	374,700	1961	+			+			2
66. Freetown	Sierra Leone	163,000	1968	+		+		+		3
67. Mogadiscio	Somalia	172,677	1967	+						1
68. Benoni	South Africa	122,502	1960							—
69. Bloemfontein	South Africa	112,606	1960							—
70. Cape Town	South Africa	508,341	1960	+	+	+	+			4
71. Durban	South Africa	560,010	1960	+	+		+			3
72. East London	South Africa	113,746	1960	+	+					2

Table I (cont.)

No. City	Country	Population	Date	Land-sea border	River	Relief	Geol. struct.	Soil	Cli-mate	Number of correlations
73. Germiston	South Africa	148,102	1960				+	+		2
74. Johannesburg	South Africa	595,083	1960				+			1
75. Pietermaritzburg	South Africa	(128,598)	1960		+			+		2
76. Port Elizabeth	South Africa	249,211	1960	+						1
77. Pretoria	South Africa	303,684	1960		+					1
78. Springs	South Africa	137,253	1960					+		1
79. Bulawayo	Rhodesia	200,000	1966					+		1
80. Salisbury	Rhodesia	172,000	1966			+	+			2
81. Khartoum	Sudan	189,000	1967		+				+	2
82. Omdurman	Sudan	201,000	1967		+				+	2
83. Lome	Togo	(139,800)	1968	+				+		2
84. Tunis	Tunisia	468,997	1966	+						1
85. Kampala	Uganda	(123,332)	1959		+		+			2
86. Alexandria	U. A. R.	1,801,056	1966	+					+	2
87. Asswan	U. A. R.	127,594	1966		+		+	+		3
88. Asyut	U. A. R.	153,956	1966		+					1
89. Cairo	U. A. R.	4,219,853	1966		+	+	+			3
90. Damanhur	U. A. R.	146,079	1966		+					1
91. El Mahalla el Kubra	U. A. R.	225,323	1966		+					1
92. Faiyum	U. A. R.	133,616	1966				+	+		2
93. Giza	U. A. R.	571,249	1966		+			+		2
94. Imbaba	U. A. R.	182,000	1965		+					1
95. Ismailia	U. A. R.	144,163	1966						+	1
96. Mansura	U. A. R.	191,459	1966		+					1
97. Minya	U. A. R.	112,580	1966		+		+			2
98. Port Said	U. A. R.	282,977	1966	+						1
99. Subra el Khema	U. A. R.	172,902	1966		+					1
100. Suez	U. A. R.	264,098	1966	+						1
101. Tanta	U. A. R.	229,978	1966		+					1
102. Zagazig	U. A. R.	151,186	1966		+					1
103. Dar es Sálam	U. R. Tanzania	272,821	1967	+						1
104. Kitwe	Zambia	(146,000)	1966		+					1
105. Lusaka	Zambia	(152,000)	1966		+					1
106. Ndola	Zambia	(108,000)	1966				+			1
				33	58	21	35	25	24	

* urban agglomeration

and not the map scale. In fact, more detailed material would cause an increase in the number of correlations with relief, rivers, geological structure and soils. Nevertheless, it seems that even detailed material would not disturb some of the general relationships that arise from the presented Table, with water systems exerting the biggest influence upon the location of urban settlements.

The most unexpected feature is the high correlation between the urban location and changes within the geological structure. It is not known whether this would remain unchanged in the case of using more detailed material. Anyway, even so, it is likely to remain rather close. Change within the remaining elements seems to play a more or less similar role.

TABLE II

Number of environmental changes	0	1	2	3	4	5	6	In total
Number of towns	8	33	36	24	5	—	—	106
Percentage	7·5	31	33·9	22·6	4·7			99·7

Table II is a recapitulation of the last section of Table I. At the top of this table the values from 0 to 6 indicate the number of correlations, whereas at the bottom, the number of corresponding towns is stated. Thus, over 60 per cent of urban places are located where at least two elements within the geographical environment vary. Upon possession of more detailed material concerning environmental change the above mentioned percentage would be higher, as some of the towns not showing any correlations (column 0) or correlating with only a smaller number of elements would be transferred to higher classes.

Concerning the question of the relationships between urban location and the geographical environment we can thus assume that the towns of Africa are most frequently located in places where at least two elements of the geographical environment are subject to significant variation.

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PROBLEMS OF MAN AND ENVIRONMENT IN SOME URBAN AREAS OF JAPAN

by

T. NAKANO

ENVIRONMENTAL PROBLEMS IN JAPAN

Urban areas have been studied by geographers, for instance, from the viewpoints of urban morphology, urban history and urban function. Although physico-geographical studies have not always been considered an important subject, according to the development of urban areas, the physical conditions have been strongly influenced by air pollution, water pollution, soil pollution and land subsidence. Pollution of the biosphere in urban areas has also become an important problem for mankind.

Land subsidence is one of the most representative problems in Japanese urban areas. Land subsidence due to the abstraction of groundwater for industry, city-water supply, and hospitals is occurring in Tokyo, Osaka, Nagoya, Yokohama, Niigata, Kochi and other cities. Land now below sea level due to subsidence covered more than 450 sp.km in 1970 and the estimated number of population in such areas exceeds 5 millions.

As a result of land subsidence, the following problems of environmental pollution occur.

(1) Salt water encroachment into the groundwater.

(2) Lowering of the ground level and the formation of land below sea level which is endangered by natural hazards, particularly by floods and high tides.

(3) Decrease in the ability of rivers to discharge naturally and the accumulation of water pollutants.

(4) Biospheric pollution.

(5) The necessity to raise bridges and dikes, and the disturbance of traffic flow as a result.

(6) Inefficiency of dikes and sea walls against floods and high tides and increased dangers of floods due to the breaches of dikes and sea walls by earthquakes.

Such successive, unexpected and harmful results now constitute one of the big problems of the governmental and prefectural authorities in Japan.

CHARACTERISTICS OF LAND SUBSIDENCE IN JAPAN

The author has studied such problems within the context of the urban geography of Tokyo, Nagoya, Niigata, Kochi, Shizuoka etc. and their environs. Briefly reviewing the case of Tokyo area, the author would like to describe several of the characteristics of land subsidence. Similar problems will be treated for other urban areas in Japan.

(a) Land subsidence due to abstraction of groundwater as observed in Tokyo, Osaka, Nagoya, Kochi etc., and

(b) land subsidence due to the production of natural gas together with groundwater as in Niigata and Funabashi near Tokyo, are classified in Japan.

Concerning (a), groundwater for industry and buildings has been pumped from both diluvial and alluvial aquifer beds, the depth of wells progressively becoming deeper during the last 20 years. Before 1950, most of the deep wells were not abstracting groundwater from more than 100 metres below the surface. After the establishment of the Law on Industrial Water, the depth of wells became deeper and at present in the Tokyo area most of the deep wells go down more than 200 metres. The rate of land subsidence exceeds 100 mm/year in areas covering more than 30 sq.km and is greater than 200 mm/year in the south-eastern part of Tokyo. The expansion of land below sea level has progressed year by year and will continue until land subsidence ceases.

Type (b) land subsidence is occurring in Funabashi city near Tokyo in the same groundwater basin. The annual amount of subsidence is greater than 200 mm/year and the subsiding area is restricted to the area where natural gas wells are in operation at a depth of 900 to 2,000 metres. Due to such rapid subsidence the area of land below sea level is rapidly expanding and became connected with that of the Tokyo area several years ago. Type (b) subsidence also exists in the diluvial upland of the adjacent area, where it is caused by the abstraction of both natural gas and water. In the lowland area, consisting of alluvium of several 10 metres of thickness and of about 400 metres of diluvium, land subsidence is also caused by pumping groundwater from water-bearing Pleistocene layers. However, the proportion of land subsidence due to the compaction of natural gas-bearing layers amounts to more than 95 per cent of the total. In the area concerned, the annual speed of crustal movement is calculated as being several mm. The rapid land subsidence can only be understood by the rapid compression of Tertiary formations due to the production of natural gas.

LAND SUBSIDENCE IN THE KOCHI AREA

Land below sea level covers an area of about 10 sq.km in the Kochi city area of Shikoku, Southwest-Japan. The formation of land below sea level in this area has been explained as follows:

(a) land reclamation during the feudalistic period,

(b) subsidence due to crustal movements, particularly to earthquakes,

(c) as mentioned in section 2 (a) and (b),

(d) land subsidence presumably due to the use of groundwater for industry, buildings and city-water supply.

The downtown area of Kochi was mostly reclaimed during the Edo period and continued until about 100 years ago. Originally, such reclaimed lands were below high tide level and were further lowered due to discharge and the successive compaction of the surface. Such lowered reclaimed lands were sometimes inundated by the sea during high tides due to typhoons and tsunami tidal waves.

Generally speaking, the annual vertical movement of land is estimated at about 3—5 mm with subsidence in lowland areas and upheaval in mountainous areas being generally characteristic. In addition, acute subsidence and uplift due to earthquakes should be mentioned.

In the Kochi area, the annual vertical movement is estimated at about 5 mm while the acute subsidence due to the Nankai earthquake in 1946 was reported to have caused a subsidence of about 120 cm, of which about 40 cm was recovered within 100 days after the earthquake. The upheaval of lowland areas was first accurately measured by precise levelling in 1954.

However, subsidence of the land was also reported after a second levelling operation conducted in the deltaic lowland as shown in Table I.

TABLE I

Change in ground level

I. Results of the first levelling

	1951—1952	1952—1953	Elevation in 1953
B. M. 1	— 9·7 mm	—15·1 mm	1·9844 m
B. M. 2	— 3·2 mm	—20·1 mm	0.5514 m
B. M. 3	+23·8 mm	—15·0 mm	—0·7940 m
B. M. 4	+37·2 mm	+ 7·4 mm	0·5218 m
B. M. 5	+26·6 mm	—19·3 mm	—0·5963 m
B. M. 6	+ 1·6 mm	+ 5·3 mm	0·5941 m

II. Results of the second levelling from February 1970 to February 1971

B. M. 5003	—30·0 mm	including land subsidence due to the abstraction of groundwater
B. M. 10880	—39·4 mm	
B. M. 10881	—48·7 mm	
B. M. 10883	+ 6·0 mm	corresponding to vertical crustal movements
B. M. 10884	+ 4·0 mm	
B. M. App. 13	+ 4·4 mm	

According to city-planning maps at scales of 1 : 3,000 and 1 : 2,500, in 1959 and 1969 respectively, remarkable differences in ground level have occurred over the period.

Although complicated conditions exist such as land dislocation and deformation before and after earthquakes, general trends in land subsidence in the deltaic region of Kochi city can be summarized as follows:

Before the earthquake	land generally subsiding at several mm/year
Nankai earthquake in 1946	acute subsidence of 120 cm
Immediately after the earthquake	about 40 cm of upheaval within 100 days
After the earthquake	slow upheaval
Since 1950	natural subsidence together with land subsidence due to other causes. Rate of land subsidence is increasing.

Generally speaking, post-war industrialization and urbanization started in Japan in about 1950. In the early 1950s, industrialization was rejuvenated in the former industrial regions, for instance Tokyo, Osaka and Nagoya. After 1955, industrialization in local cities was promoted by local government with the financial assistance of the national administration.

Kochi city, damaged by the war in 1945 and the earthquake in 1946, was energetically reconstructed on the basis of a newly devised city plan. New buildings furnished with deep wells for air conditioning have been constructed in the centre of the city. The population of the urban area has increased from about 196 thousands in 1960 to 240 thousands in 1970, despite a decrease in the population of the central zone. Industries such as cement, textiles, paper, chemicals and ship-building are also developing in the city area.

Such development results in an increase in the use of groundwater. According to data on groundwater use, 137,800 tons/day is being abstracted within the city area of about 25 sq.km. This means that groundwater use per sq.km per day is about 5,512 tons. This is between 1·5 and 2 times that of the Tokyo downtown area. On the basis of geological profiles it is considered that this amount of groundwater has been taken from the alluvium and diluvium, and accounts for the salt water encroachment in the deltaic area of Kochi city.

Due to the progress of land subsidence, it is clear that land below sea level is constantly being formed and is expanding. The area of land below sea level was about 8 sq.km in 1959, rising to 10 sq.km in 1969, and is expected to advance to about 12 sq.km in 1980. It is also clear that environmental conditions will become worse and the danger from natural hazards such as heavy rains, typhoons, earthquakes and accompanied tsunami, earthquake floods due to the breaching of banks and dikes, will increase.

For summarizing the changes in urban environment due to land subsidence, the following simplified flow chart has been compiled.

(1) Land, water, air, biosphere etc. as environmental factors.

(2) The natural environment of urban areas.

(3) The development of urban land use including industrial areas, buildings, and facilities for city-water supply using groundwater.

(4) Imbalance in discharge and processing facilities of used water and increase in water use.

(5) Salt-water encroachment, lowering of groundwater table.

(6) Land subsidence.

(7) Lowering of ground level.

(8) Increase in flooding during normal rainfall.

(9) Increase in danger from large-scale natural hazards such as river floods, high tides, earthquake tsunamis and earthquake floods.

(10) Increase in water pollution due to water stagnation.

(11) Changes of the biosphere due to water pollution.

In case of Kochi, the area of land subsidence is also exposed to the danger of earthquakes. The percentage of damaged wooden houses was more than 25 per cent in Nankai earthquake of 1946.

The area below sea level was severely inundated by high tides due to Typhoon No. 10, the inundation covering more then 10 sq.km and the number of flood sufferers amounting to more than 30,000. The number of people whose houses were destroyed or partly damaged covered more than 42,000 persons.

This damage may be explained in the following way:

(1) Abnormal high tides in the bay due to typhoon.

(2) The coincidence of high tide with astronomical tides.

(3) The lowering of land due to land subsidence and the poor discharge ability of the urban area.

After the flood disaster, the interview survey method prepared by the IGU Commission on Man and Environment was applied to the area. 93 persons out of the 116 persons interviewed pointed out the problems of flood disasters and about 50 per cent spoke of the high possibility of natural hazards due to typhoons each year.

However, 90 per cent of the people living in the inundated area wanted to stay in the same place. These people require the solution of the following problems:

(1) The provision of accurate information before natural hazards.

(2) The construction and reconstruction of protection facilities such as dikes, discharge pumping stations etc.

(3) Insurance for damage.

(4) Reconsideration and revision of industrial development in Muroto Bay including the broadening of the bay mouth in order to increase navigational safety.

In conclusion, attention should be drawn to the following:

The urban environment is being rapidly changed by man and the development of urban areas should serve public welfare. Planning for urban and regional development should be based on a thorough knowledge of the environmental changes being so induced.

RELATIONSHIPS BETWEEN ENVIRONMENTAL FACTORS AND THE FREQUENCY OF GASTRIC CANCER IN EASTERN TRANSYLVANIA (ROMANIA)

by

S. JAKAB, G. MÁLNÁSI and P. GYÖRGY

The present paper contains a summary of data resulting from our investigations which aim to establish any possible correlations between geographical factors and the incidence of gastric cancer in the Harghita and Mureş counties of the Socialist Republic of Romania. These two areas of 13,300 sq.km and with a population of 819,000 inhabitants at the time of our investigations in 1961—1968 essentially differ in terms of physical and economic features. They are situated in the center of the country in the eastern part of Transylvania (Fig. 1).

The first, the typical mountainous area of Harghita county, is a region formed by the Ciuc and Gheorgheni intermontane depressions, encircled by the 1,500—1,800 m high mountains of the Eastern Carpathians. Its settlements are situated at 650—900 m above sea level. The second hilly area of Mureş county situated in the Central Transylvanian table-land, presents distinct geographical features. Relief ranges between 270 m absolute altitude in the large valleys, and 500 m on the interfluves.

Great geographical contrasts are necessary to test gastric cancer morbidity under essentially different environment circumstances.

Cancer case occurrences were obtained by using the data of the County Cancer Register, the County Statistical Bureau and personal data collected at the level of rural public health district centres. All referred to cancer morbidity and mortality registered during the years 1961—1967.

RESULTS

When standardized data for the mountainous area were compared with those registered for the hilly country (Mureş county), a gastric cancer mortality ratio two and a half times larger in the first than in the second area was found (Table I).

There is general agreement that in some cases the natural environment influences gastric cancer incidence by some up to now unknown factors which may have certain stimulatory or inhibitory biological effects.

GASTRIC CANCER INCIDENCE AND ALTITUDE

In both Harghita and Mureş county, in almost all settlements, gastric cancer incidence seems to be directly proportional to altitude above sea level. The relatively high geographical location and closed intermontane depression

Table I

The incidence of gastric cancer per 100,000 inhabitants per year

Area	1961—1967	1961	1962	1963	1964	1965	1966	1967	Number of inhabitants
Intermontane depressions of Ciuc and Gheorgheni	47·29	56·76	42·20	46·52	48·38	51·58	41·00	37·63	182,300
Hilly area of Mureş county	17·24	21·74	17·00	12·69	18·63	18·73	19·33	17·10	309,500
Transitional area	28·87	34·91	31·54	25·49	21·34	25·66	36·17	30·28	237,200

Table II

Climatic data

Area	Temperature °C			Cloudiness	Bright weather days	Cloudy days	Overcast days	Frosty days	Winter days	Summer days	Precipitation (mm)
	Mean annual temp.	July	January								
Intermontane depressions	5·6	16·0	—6	35·8	120·0	89·6	155·4	160·5	55·4	34·8	608
Hilly area of Central Transylvania	8·7	19·6	—4	35·6	123·4	109·5	132·1	127·2	40·7	81·7	646

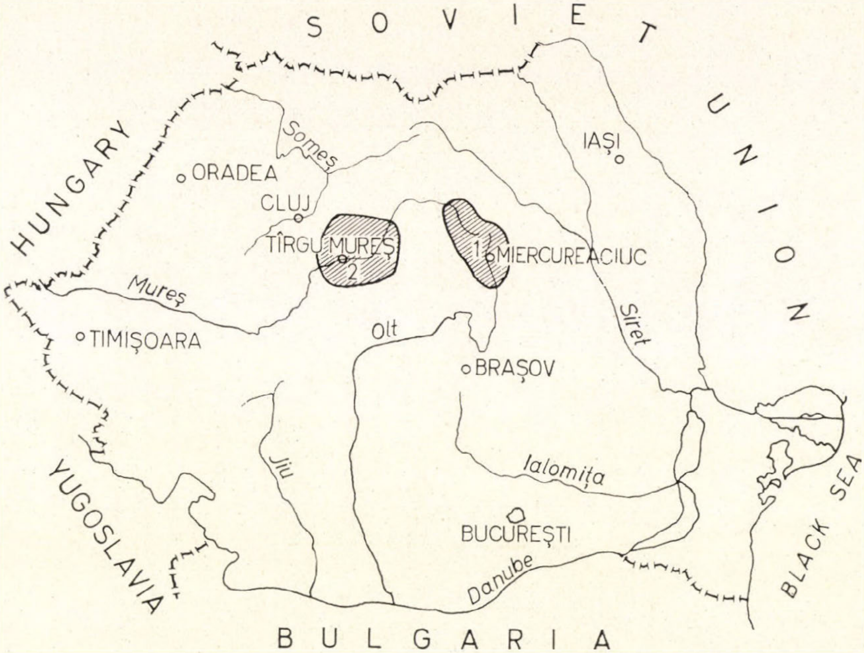

Fig. 1. Location map
1 — Intermontane depressions; 2 — Hilly area of the Central Transylvanian table-land

character of the first area implies a cold climate, and little variety of natural and cultivated plants, e.g. potatoe and rye monoculture in the Gheorgheni Depression. This contrasts with the lower altitude and milder climate of the second area, and its much wider range of fruit, grapes and vegetables (Table II).

As the diet of the rural population is mainly derived from local agricultural products, the nature and diversity of which strongly depends upon climatic factors, diets are rather different in the two contrasted areas, as shown by year long studies of families in two villages, the one in the intermontane depression of Gheorgheni and the other in the hilly area of Mureş county. The results were very surprising. In the intermontane depression twice as many potatoes were consumed as in the hilly area. The diet of the inhabitants of the intermontane depression shows a lack of fruit, fresh vegetables and grapes, while in the Central Transylvanian hilly area these foods are consumed abundantly. The consumption of smoked-meat in the hilly area is somewhat higher, but in the intermontane depression of Gheorgheni twice as much smoked-bacon and concentrated alcohol are consumed.

The specialist literature demonstrates that in regions where the consumption of maize flour is high, gastric cancer is scarce. We note that the average person living in the hilly area consumes 74 kg maize flour yearly, compared with only 7 kg in the intermontane depression (Fig. 2).

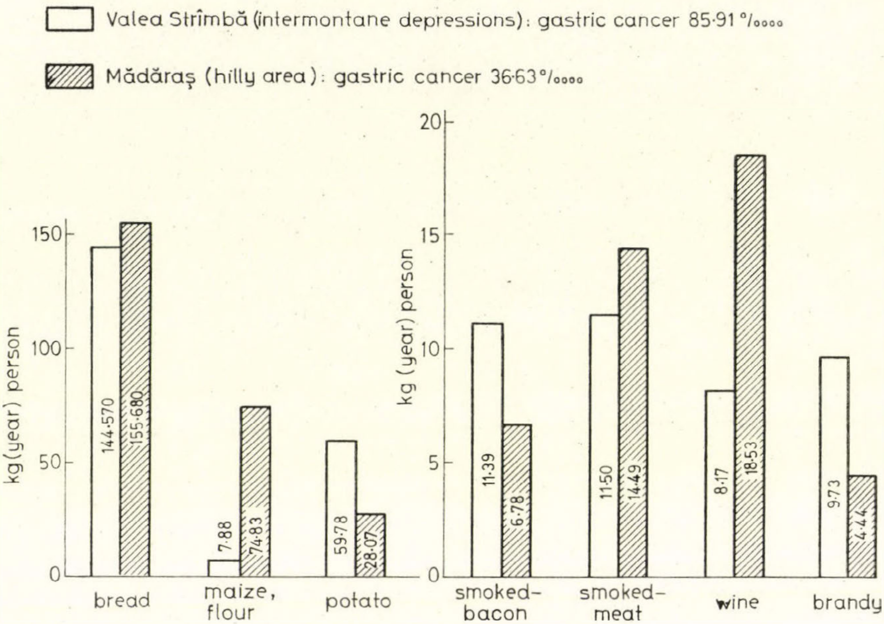

Fig. 2. The consumption of certain food-stuffs in Valea Strîmbă, a village in the intermontane depression and Mădăraş, a village in the hilly area

Without aspiring to conclusions, it is interesting to speculate on the possibility that the decreasing consumption of bread, potatoes, smoked-bacon and smoked-meat and increasing consumption of vegetables and fruits will be followed by a diminution of gastric cancer morbidity in the Ciuc and Gheorgheni intermontane depressions, as was the case in the USA over the last 30—40 years.

GEOLOGICAL AND PEDOLOGICAL FACTORS AND THE INCIDENCE OF GASTRIC CANCER

The intermontane depression are bordered by mountains 1,500—1,800 m high consisting of volcanic metamorphic and cretaceous sedimentary rocks (andesites with a content of more than 50 per cent SiO_2, micaschists, quartzit schists, paragneiss and sandstone, respectively). The bottom of the depressions comprises alluvial and proluvial deposits originating from the surrounding mountains, and is marshy in the central parts. Peats, peaty soils and gley soils cover most of the of central part of the depressions. On the border of the depressions highly gleyed brown podzolic soils, all with low pH values and a high content of high radiating organic material are found (Fig. 3).

It is important to emphasize the presence of volcanic andesites and sienites and peat, because as shown by M. Segi and N. Kurihara (1960) and P. Stocks

(1957) the frequency of gastric cancer is higher on such geological formations than in other regions.

In the Gheorgheni Depression, where the soil cover and parent material are relatively homogeneous and all rural settlements lie, at least partly, on poorly drained peaty soils or on volcanic substratum, the incidence of cancer, especially gastric cancer morbidity is uniformly high, namely $78^{0}/_{0000}$ per year for men and $71^{0}/_{0000}$ per year for women. This equals the values in Japan, Iceland and Chile.

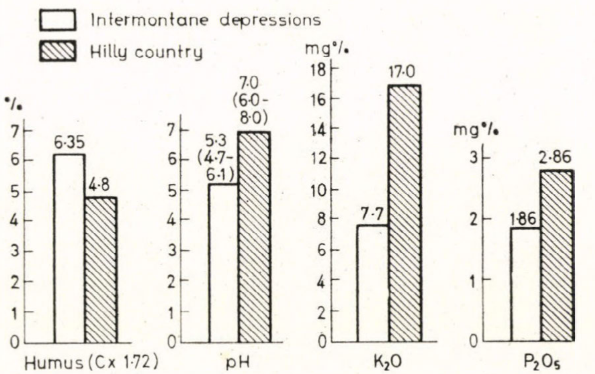

Fig. 3. Some average chemical characteristics of the soils

The geological and geomorphological structure of the Ciuc Depression is more varied, being divided into three compartments by two volcanic thresholds. The soil cover is somewhat more varied also. Settlements lie on peat with a high phreatic water level and on well-drained andesitic gravels, sand-

TABLE III

Rural settlements in the Ciuc intermontane depression lying partly on andesite or on peat with a high incidence of gastric cancer

Villages	Gastric cancer per $^{0}/_{0000}$/year	Observation
1. Satu Nou	210·0	
2. Mihăileni	142·7	
3. Racu	136·7	
4. Jigodin	133·6	
5. Mădăraş	129·0	
6. Cetăţuia	94·2	
7. Sîntimbru	82·0	
8. Topliţa Ciuc	79·3	
9. Sînsimion	74·0	
10. Ciceu	73·9	
11. Sîncrăieni	72·2	
12. Siculeni	36·5	exception

stone-gravels, cretaceous sandstones, sandy terraces and metamorphic rocks Here the incidence of gastric cancer morbidity is varied. High morbidity tends to occur in villages, situated at least partly on adesitic rocks or peat, while low morbidity characterizes those on sandstone, sandstone-gravels, and sandy terraces covered with brown forest soils (Tables III and IV).

TABLE IV

Rural settlements in the Ciuc intermontane depression lying on formations other than andesite or peat with a low incidence of gastric cancer

Villages	Gastric cancer morbidity °/₀₀₀₀/year	Observation
1. Frumoasa	102·5	exception
2. Armăşeni	62·1	
3. Bancu	60·1	
4. Leliceni	54·7	
5. Dăneşti	50·5	
6. Tomeşti	48·1	
7. Ciuc Sîngheorghiu	46·5	
8. Tuşnad Sat	42·6	
9. Nicoleşti	42·5	
10. Cîrţa	41·8	
11. Păuleni	36·7	
12. Misentea	33·1	
13. Ineu	31·5	
14. Lăzăreşti	22·9	
15. Nădejdea	18·8	
16. Ciucani	12·7	

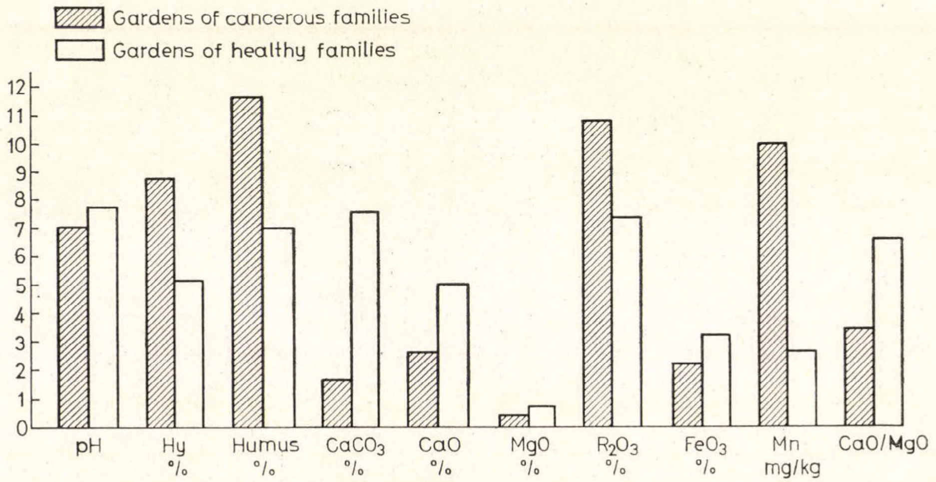

Fig. 4. Soil analysis data from Palanca, Upper Trotuş valley

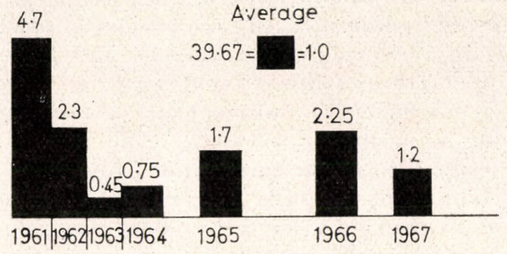

Fig. 5. The incidence of gastric cancer in the Lunca de Sus rural health district (Harghita County) consisting of 14 households. The average annual incidence of gastric cancer per 100,000 inhabitants over the period 1961—1967. The general average of 39·67 is considered equal to 1

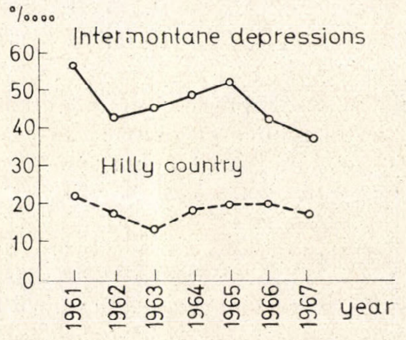

Fig. 6. The incidence of gastric cancer in the intermontane depressions of Ciuc and Gheorgheni and in the hilly country of the Central Transylvanian table-land

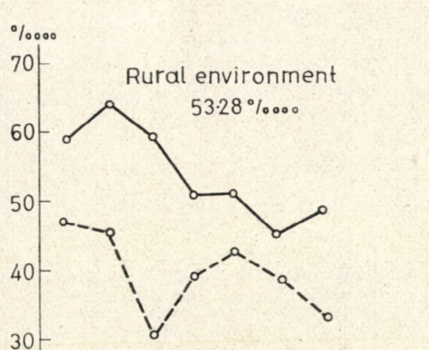

Fig. 7. Gastric cancer in rural and urban areas in Harghita and Mureş counties

Similar situations can be observed over quite small areas, for instance, in a single scattered community, if the geological, pedological and hydrogeological conditions are variable, as is the case in Palanca and Lunca de Sus, villages in the upper Trotuş valley (Fig. 4).

Lunca de Sus consists of 14 households, scattered along both the main Trotuş valley and in narrow side-valleys. The incidence of gastric cancer morbidity differs significantly in each valley (Fig. 5).

In the hilly country of the Transylvanian table-land, moulded in clayey marl and marl, and covered by neutral or basic clay black soils, chernozem-like brown soils and brown forest soils of low organic content, gastric cancer morbidity is everywhere uniformly low (Fig. 6).

All urban settlements, for instance Miercurea Ciuc, Balan, Tuşnad, Bai, Tîrgu Mureş, Tîrnaveni and Luduş exhibit low gastric cancer morbidity, independently of any environmental factors (Fig. 7).

DRINKING WATER AND THE OCCURRENCE OF GASTRIC CANCER

As R. C. Turner (1962) has established, in mountainous regions with soft water and low pH's, the incidence of gastric cancer increases. In the high gastric cancer areas of the Ciuc and Gheorgheni intermontane depressions, both the river and underground water is soft, while in the hilly area the water is hard (Fig. 8).

In the Central Transylvanian hilly area (Mureş county) five times more bicarbonate-salts, six times more sulphates and chlorides, three times more fluorine and twelve times more iodine are consumed in the drinking water than in the intermontane depressions.

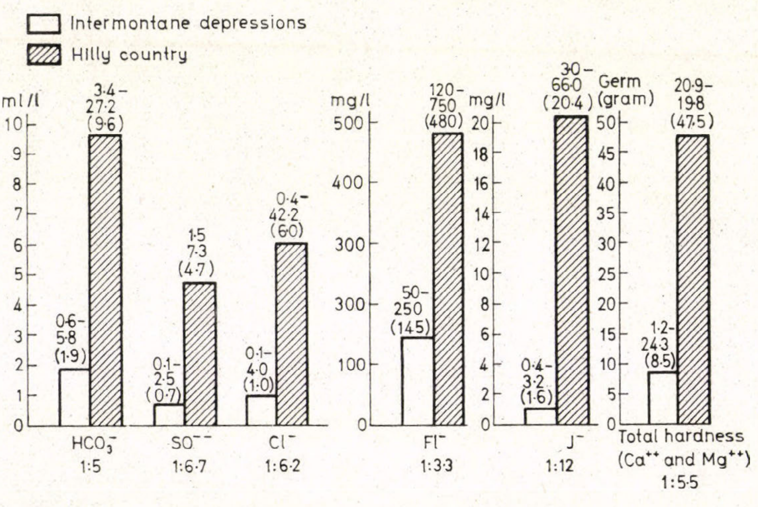

Fig. 8. The soluble salt content of drinking water

But people living in the Ciuc and Gheorgheni intermontane depressions drink almost exclusively mineral water. Many hundreds of springs contain dissolved carbon dioxide gas, as well as the mineral constituents of the volcanic rocks, through which they pass. Almost all of them, namely more than six hundred, were recently submitted for chemical analysis, including trace-element determination.

The majority of these mineral waters, in general, contain carbonic acid, calcium, magnesium, bicarbonates, sodium chloride, sulphate and nitrates. Some of them have a surprisingly high content of potassium. The drinking of these mineral waters during a life-time, may have certain biological consequences, although the carcinogenic or anti-carcinogenic significance of these mineral elements still remains obscure. Although up to the present no concrete data exist, such global effects upon the entire population cannot be excluded, since waters of high mineral content are absent in the "low carcinogenic" hilly area. This problem needs further research.

THE RADIOACTIVITY IN DRINKING WATER AND FOOD IN THE INTERMONTANE DEPRESSIONS

The Rn^{222} and Ra^{226} content of more than 40 water sources in the intermontane depressions was tested. The Rn^{222} content alternates between $0{\cdot}04$ and $3{\cdot}78\times10^{-9}$ Ci/litre and the Ra^{226} between $0{\cdot}3$ and $151{\cdot}4\times10^{-12}$ Ci/litre. The values are, in some cases, over by the ICRP admitted level.

The permanent consumption of such water over a life-time of 70 years can lead to accumulations of radium in excess of the level admitted by ICRP.

The carcinogenic nature of these waters, however, remains questionable. It can be shown, that no case of gastric cancer was detected during the past eighteen years among household members, and their ancestors, drinking highly radioactive water for many decades of their life. On the other hand, several new cases of gastric cancer were registered in areas of water of low radioactivity.

There are considerable variations in the food-stuffs originating from the different settlements of the two areas. This depends, on the one hand, on the internal difference between the food-stuffs in question and on the other, on environmental factors, particularly on the geological, pedological and hydrogeological conditions.

The most important radioactive element in many of the tested food-stuffs, vegetables and fruit is K^{40}. It can also be demonstrated that the radioactivity of food-stuffs derived from a restricted region with higher natural background radiation is similarly higher, e.g. in the Gheorgheni Depression and its surroundings (Szabó *et al.*, 1970).

CONCLUSIONS

1. The incidence of gastric cancer in Eastern-Transylvania is higher in the intermontane depressions of the Eastern Carpathians than in the hilly country of the Transylvanian table-land.

2. The high incidence of gastric cancer in the intermontane depressions seems to correlate with:

— a restricted diet determinated by local environmental conditions, chiefly relief and climate;

— the presence of a volcanic substratum, peat and peaty soils, and soils with low pH values, and a high amount of radio-active organic material;

— heavy mineralization of drinking water and food-stuffs.

3. The rural farm population seems to be more exposed to the supposed carcinogenic environmental factors as a consequence of consuming locally grown produce.

4. Among the urban people living in the same environment, but supplied from elsewhere, cancer morbidity is lower. It seems that the rapid urbanization of the rural population during the last decades, and a decrease in the consumption of local products both diminish the incidence of cancer, a phenomenon that has been observed in other geographical areas and countries as well.

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MAPS OF WATER-MANAGEMENT PROPERTIES OF SOILS AND THEIR UTILIZATION IN SOIL CONSERVATION, IRRIGATION AND ENGINEERING DEVELOPMENTS

by

B. KAZÓ

Permanent soil cultivation for centuries and adverse weather conditions have led to the deterioration of soil structure and, at the same time, of the water management properties of the soils, as well. A favourable or unfavourable water regime is, however, one of the parameters of soil fertility.

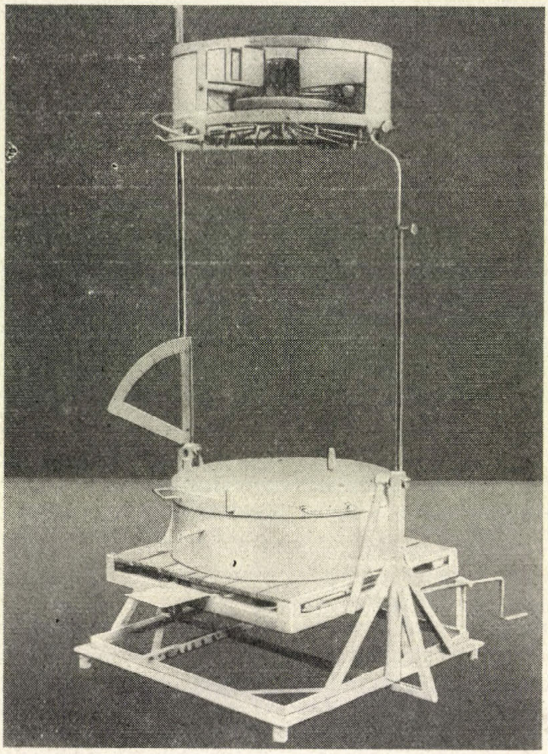
In soils of poor water regime neither precipitation, nor irrigation water can be sufficiently utilized. If the relief is also disadvantageous, such soils are often exposed to erosion hazard. To establish the rate of possible erosion damage, and to determine places in need of urgent prevention and conservation, a complex map of the water management properties of soils is needed. This map would include, besides the above-mentioned properties, the relief and the water capacity and permeability values of the different genetic horizons of soil profiles. On the basis of these maps the most appropriate agrotechnics could be selected to retain and store and make available to plants soil surface water. The selection of the appropriate agrotechnics would be very difficult, however, without a knowledge of the water management properties of the soil surface and of the fertile layers.

For this reason, the author has elaborated a new method for the preparation of general (1 : 25,000) and detailed (1 : 10,000) maps of the water management properties of soils. These latter maps give information, not only on the water regime of soils, but also on the possibilities for their cultivation.

As a first step, a genetic soil map at the proper scale is prepared. According to this map, places characteristic of the main soil types and varieties ("basic soil profiles") should be selected, where the main data for soil water management can be determined by instrumental measurements under almost natural conditions.

The natural permeability of the surface layers is obtained with the aid of the Kazó rainfall-simulator. These data can serve as threshold-values determining the amount of water storable in the lower layers. Because of the uneven distribution and different quantity of precipitation, it is difficult or even impossible to carry out comparative examinations. With the author's apparatus simulating the effect of natural precipitation, the permeability of the soil surface can be measured.

By adjusting or changing the sprinkler heads of the apparatus, an artificial rain of 4 mm drop size and of 10–60 mm/hr intensity can be produced. It is customary to set the equipment to simulate rainfall of 20 and 40 mm/hr intensities. Intensities of 20 mm/hr simulate gentle rainfall and the data received also serve to estimate the necessary rate of future irrigation. On the other hand, the values obtained with rain simulation of 40 mm/hour intensity give



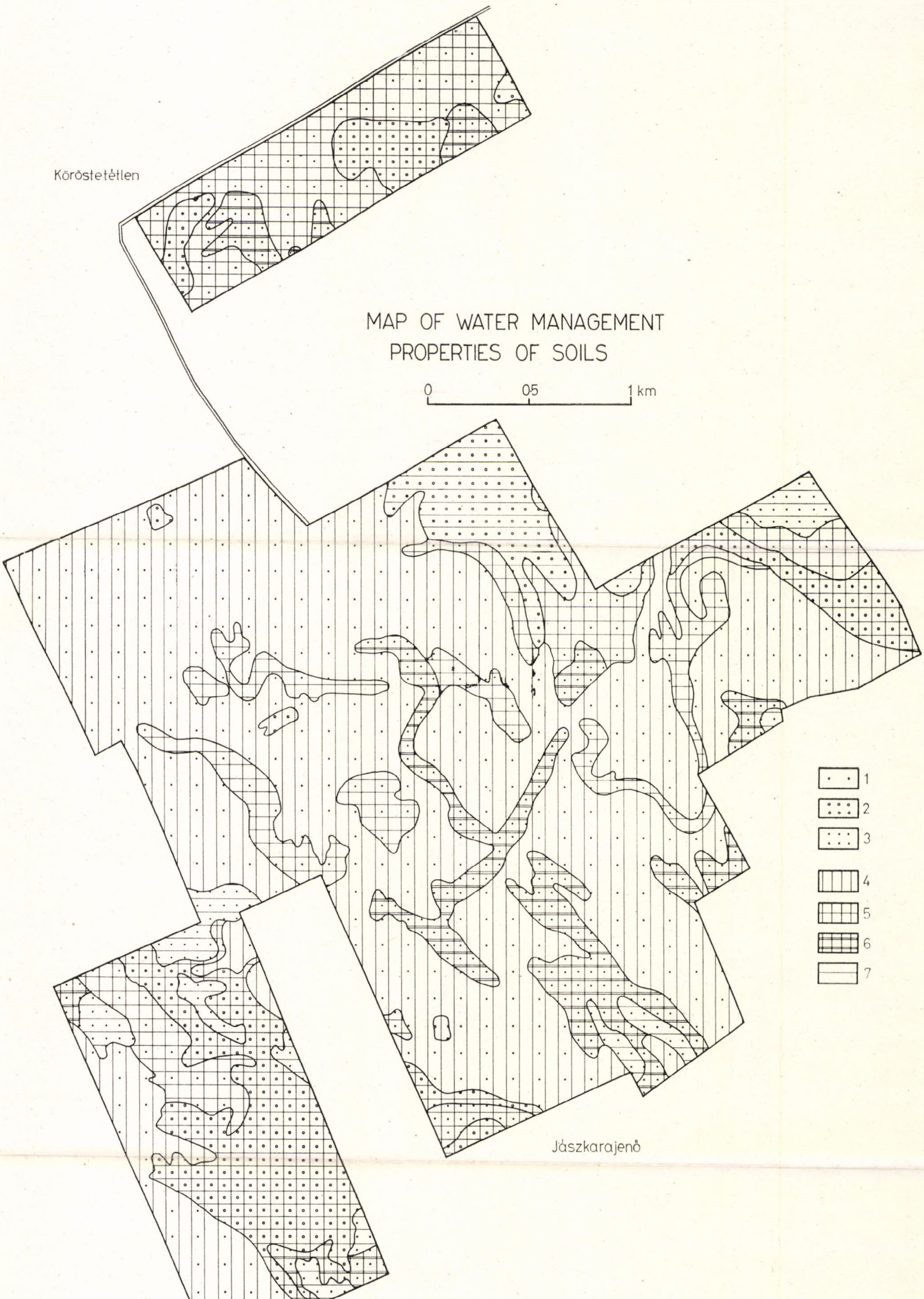
Picture 1. Rainfall simulator used in the laboratory

information on the influence of heavy rain as well as on the erodibility of soils.

The equipment consists of two parts. The device constructed for field examination registers the permeability of soils under natural conditions on a surface area of 0·25 sq.m. The natural permeability of the top layers on level land and slopes upto 40 per cent is determined with the aid of laboratory equipment and a tilting stand (Picture 1) on original structured soil monoliths of 20 cm height and 0·25 sq.m surface area (Picture 2).

The measured data are easily comparable as permeability is expressed in well defined values, i.e. in those of minimum (field) capacities. Namely, the saturation of the soil to field capacity is an identical physical state independent of soil type where it may have different values expressing absolute moisture content.

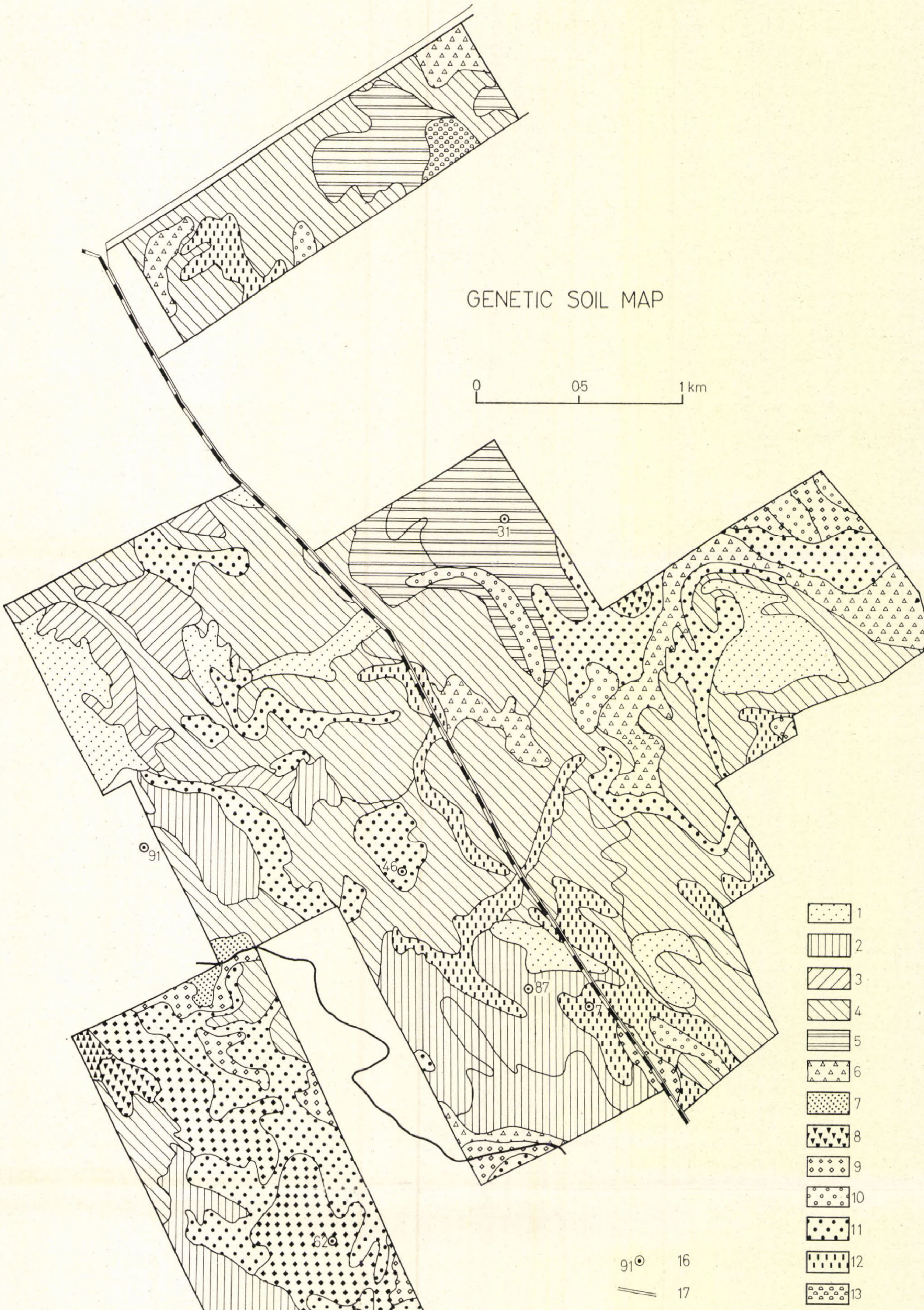
If we know the water amount necessary to saturate the soil surface to field capacity, and the run-off per unit of time, diagrams constructed on the basis of the measured values will demonstrate the permeability and run-off values according to different rainfall intensities. In this case, the "natural permeability" of the soil surface is obtained which is a permeability value



Map 2. Map of water management properties of soils

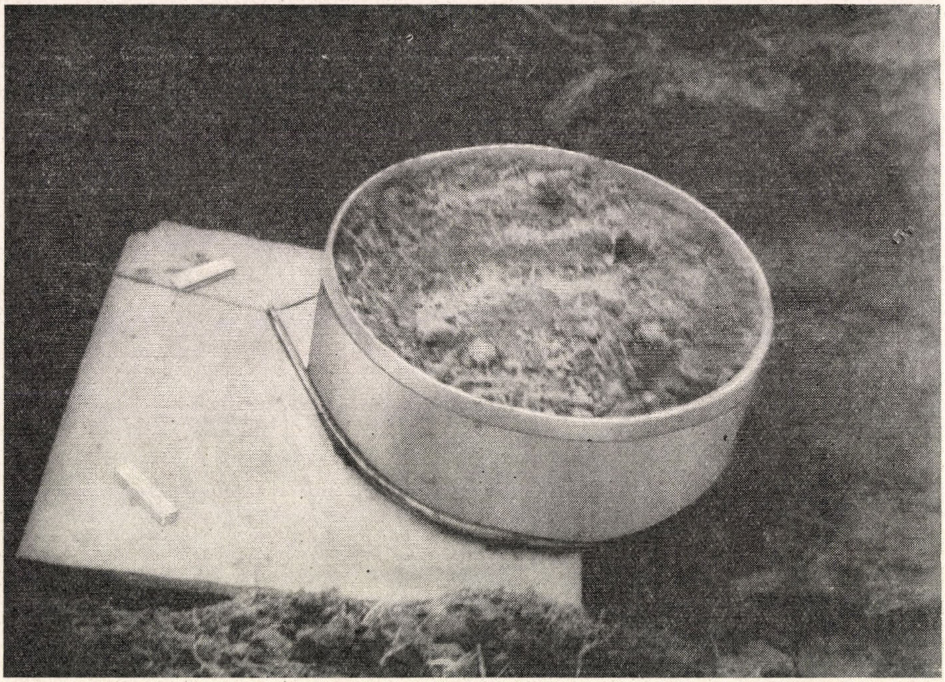
Natural permeability of surface layers measured by rainfall simulator (mm/hr) 1 — Soils with good permeability (>32 mm/hr); 2 — Soils with medium permeability (18—32 mm/hr); 3 — Soils with low permeability (0—18 mm/hr)

Permeability of the genetic horizons, determined by the "gravitational water permeabilities tube method", given in percent of the permeability of the surface layer: 4 — Soils with good or medium permeability in the whole profile (40—100% or above); 5 — Soils with good or medium permeability to the depth of 40 cm, and low permeability in one layer below this depth (0—40%); 6 — Soils with good or medium permeability down to the depth of 40 cm, and low permeability in two distant layers below this depth; 7 — Soils with low permeability in the top layer



Map. 1. Genetic soil map

Genetic types and subtypes of the soils: 1 — Calcareous, humous sandy soil; 2 — Calcareous, multilayered humous sandy soil; 3 — Calcareous chernozem; 4 — Calcareous meadow chernozem; 5 — Meadow chernozem soil, salty in deeper horizons; 6 — Meadow chernozem soil, solonetz-like in deeper horizons; 7 — Sodic solonchak; 8 — Sodic-sulfate solonchak-solonetz; 9 — Shallow meadow solonetz; 10 — Calcareous solonchakous meadow soil; 11 — Solonetzic meadow soil; 12 — Typical meadow soil; 13 — Meadow soil, salty in deeper horizons; 14 — Calcareous chernozem-meadow soil; 15 — Solonetzic chernozem-meadow soil; 16 — Basic profile; 17 — Road; 18 — Channel; 19 — Railway



Picture 2. Monolith of original structure for rainfall simulator in the laboratory

without any hydraulic forced pressure and is near to the data obtained under natural conditions.

By the use of the above-mentioned tilting stand the permeability and run-off values for different slope percentages can also be established.

The values for the natural permeability of the soil surface and for the eventual run-off are not sufficient in themselves, and one also has to know the permeability and water capacity of the subsurface layers as well. The permeability of the different genetic soil horizons is determined by the Kazó modified tube-method, without hydraulic forced pressure (Fig. 1). For this method we use on a surface area of 0·1 sq.m a porous 1 cm thick sponge layer (similar to the soil texture), saturated to water capacity, provided with automatic water supply. With the aid of this sponge layer, the steady "natural gravitational permeability" is measured over a period of one hour. The advantage of this method is that the amount of water moving under gravity can be measured in accordance with natural conditions. The gravitational water permeability can be expressed as a percentage of the permeability of the soil surface or in absolute values of mm/hour.

The water storage and water capacity of different genetic soil horizons are studied with the use of the so-called Klimes—Szmik "cartridge" samples. From the serial measurements of original structured "cartridge" soil samples, the original soil moisture content, the different water capacity values namely

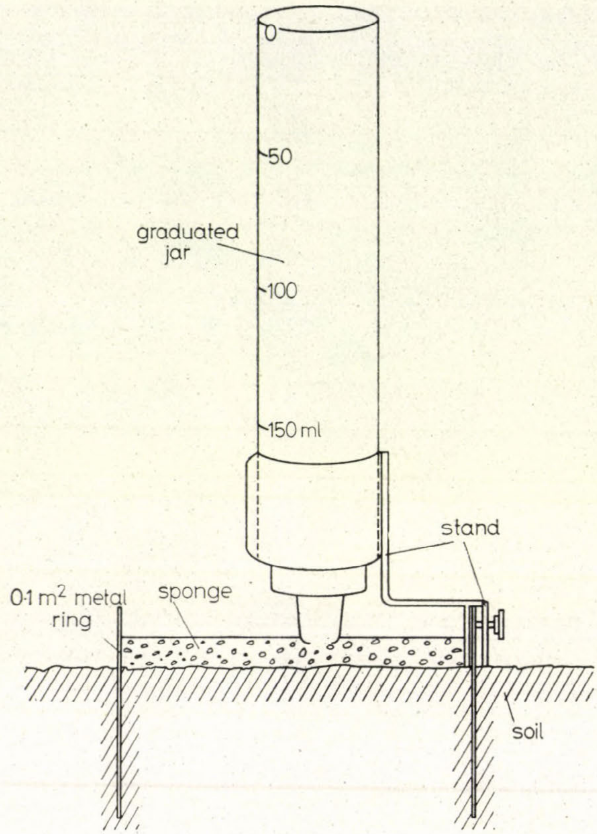


Fig. 1. Apparatus measuring gravitational water permeability

capillary, maximum and minimum water capacities, as well as the bulk density and the related porosity can be established.

On the basis of the data obtained by the author's two methods and by the "cartridge" method, the following system for preparing maps of water management properties has been elaborated.

As a model the map of a farm lying in the area between the rivers Danube and Tisza in Pest county is presented. Most of the soils of this area are chernozems (Map 1, attached), but 6 other main soil types are also to be found. The above-mentioned studies were carried out on all soil types. So for each field characteristic of the area the following is to be obtained: the basic values of the various soil water regimes (Fig. 2); the amount of available water for storage (DV), the capillary, minimum and maximum water capacities and wilting points (HV) in mm/10 cm as well as water permeability as a percentage of the permeability of the surface layers. The natural permeability of the surface layers is expressed in mm/hour intensity for the different

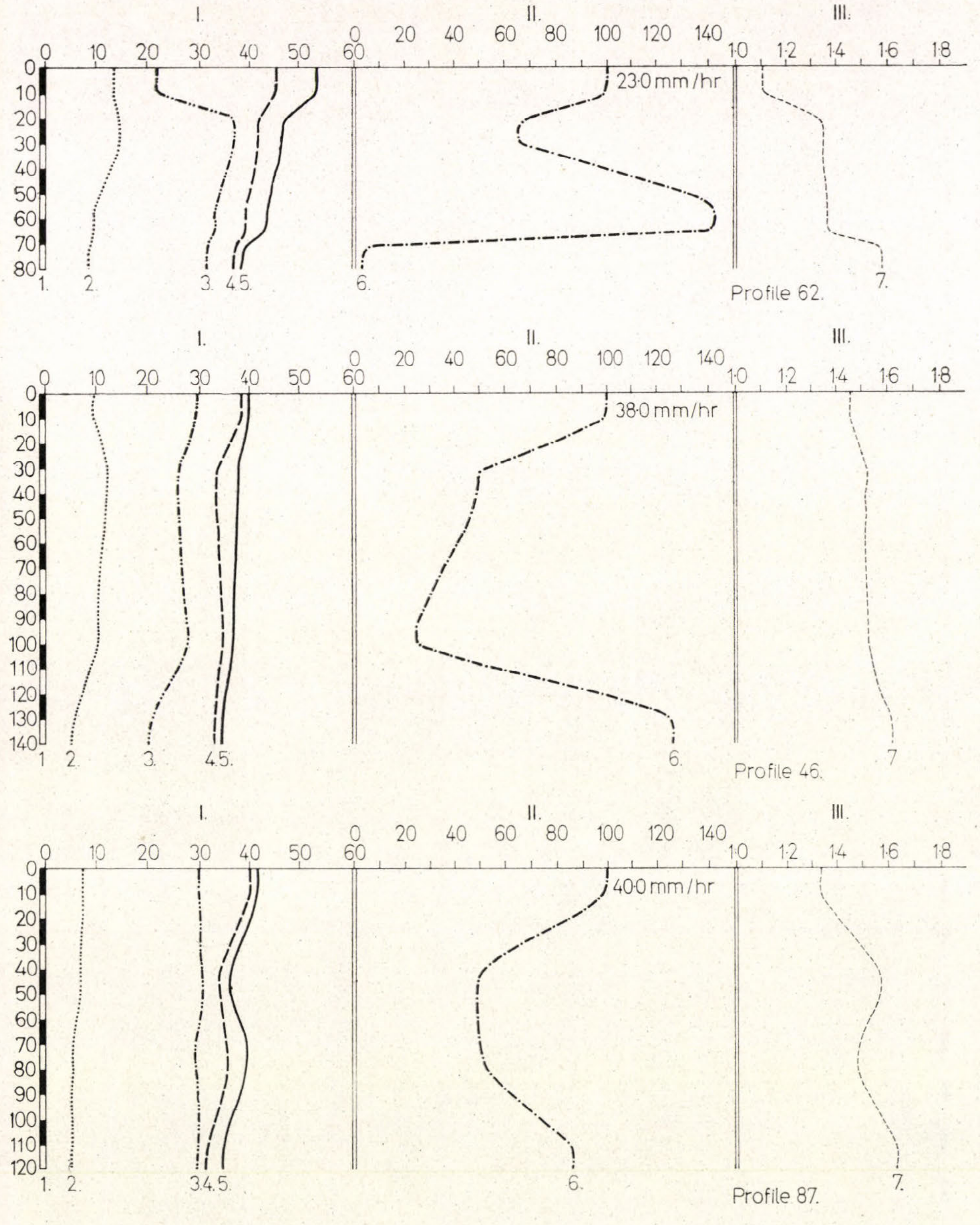
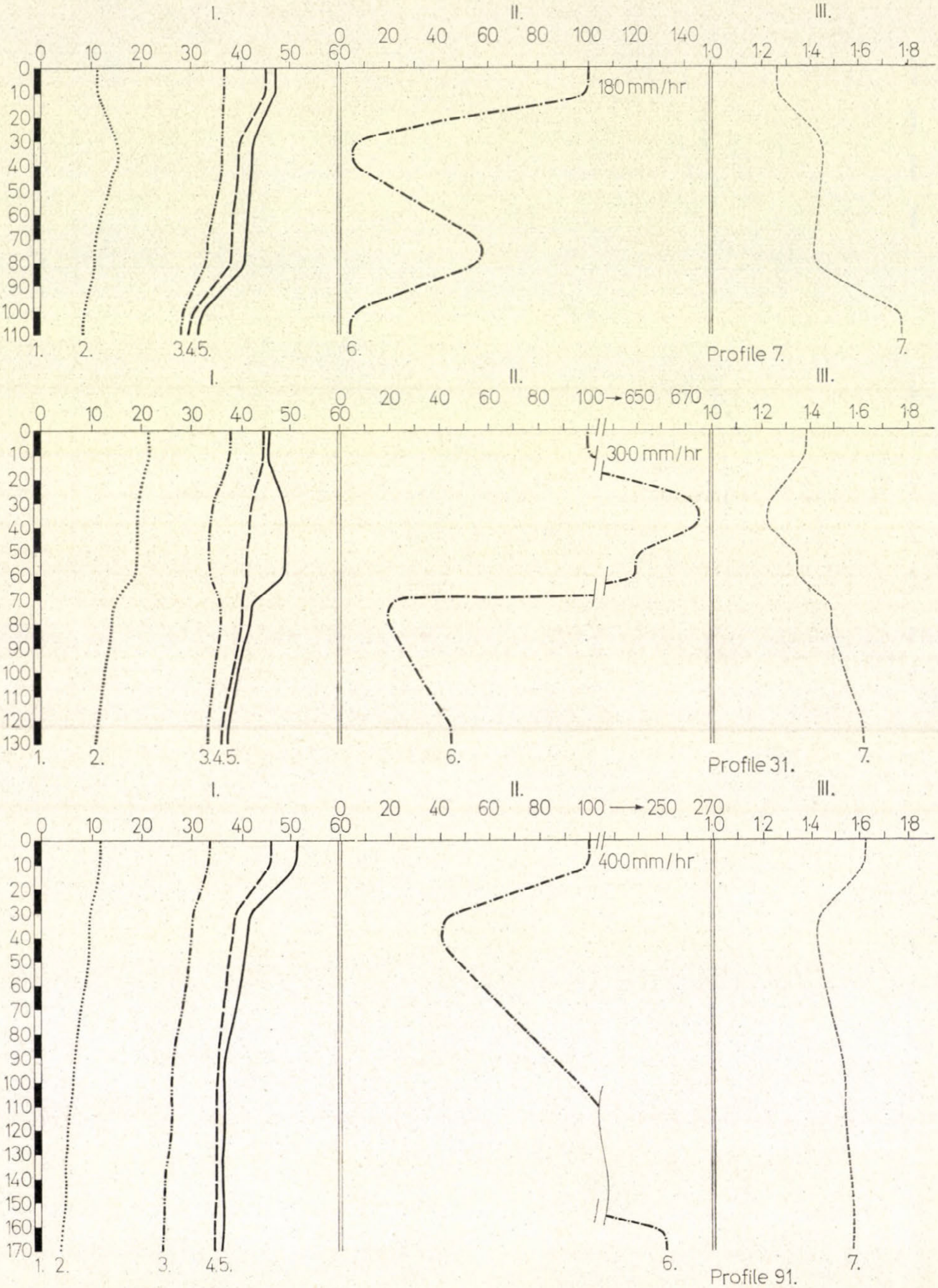


Fig 2. Water regime diagrams of the profiles examined

I. Moisture content of the soil (mm/10 cm); II. Permeability (%) given in percents of the permeability of the surface layer; III. Volume weight, per cent: 1 — Depth of the profile, cm; 2 — Witting point; 3 — Minimum water capacity (field capacity); 4 — Capillary water capacity; 5 — Maximum water capacity; 6 — Permeability; 7 — Volume weight



I.
II.
III.
180 mm/hr
Profile 7.
100 → 650 670
30·0 mm/hr
Profile 31.
100 → 250 270
40·0 mm/hr
Profile 91.
1. 2. 3. 4. 5. 6. 7.

rainfall intensities and for slope angles from 0—40 per cent. The natural water permeabilities (mm/hour) of the surface fertile layers, measured by the rainfall-simulation technique, are drawn in different hachures on the water regime cartograms (Map 2, attached).

On maps of water management properties the following parameters obtained by the three methods mentioned are illustrated: the water permeability of the surface layer as a threshold-value for the infiltration of water into the soil; run-off values related to different slope angles; and the permeability of the whole profile in absolute values or as a percentage of the permeability of the surface layer. These latter data can give information on potential subsoil defects that can reduce or even destroy the correct water regime. On the basis of these data, precise agrotechnical instructions can be given on occasional deep-ploughing and modifications suggested on the depth of general ploughing. The water storage capacity (DV), the capillary, minimum and maximum water capacities as well as the wilting point can also be established.

The map of soil water management properties is a basic map suitable for investigating the processes of present soil development, for calculating the field utilization of irrigation water and for predicting the expected rate of soil erosion. When studying the permeability of surface layers, measurements are not restricted to the rate of infiltration but include the rate of run-off as influenced by different rainfall intensities at different slope angles. Therefore the maps also provide run-off data which can be readily utilized in engineering geology, hydrology, flood-prevention and forecasting, as well as in drafting projects for drainage, reservoirs and draw-off culverts.